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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXIX No. 3 MARCH, 1929 WHOLE No. 248

THE ARRANGEMENT OF THE ELECTRONS IN THE OUTER PORTION OF THE ATOM.

BY WALTER O. WALKER,

William Jewell College, Liberty, Mo.

In a previous paper (SCHOOL SCIENCE AND MATHEMATICS, December, 1928) the writer dealt with the structure of the nucleus of the atom. Reference to that paper will indicate that our knowledge of the structure of the nucleus is exceedingly fragmentary. Beyond knowing that it is extremely small, very compact, and that it is probably made up of alpha particles, protons, and electrons we have been unable to go. The compactness of the nucleus is demonstrated by the behavior of the alpha particle in its passage through a gas. This may best be shown by means of the C. T. R. Wilson effect. This is in brief: Ions or dust particles act as centers of moisture condensation in a supersaturated atmosphere. Supersaturation results when a moisture saturated gas is expanded suddenly. If an alpha particle is shot through such a supersaturated gas, its passage will result in the ionization of many of the gas molecules or atoms in its path. If the gas has been expanded at the moment of the passage of the alpha particle, the ions become the centers of water droplets, the whole presenting the appearance of a trail of smoke or fog. In this way the path of the alpha particle may be traced. The high kinetic energy of the particle enables it to travel through many atoms without deflection. However near the end of its visible path, this particle may be deflected. (This occurs only in relatively few cases.) This deflection is now generally assumed to be due to close contact with the nucleus of the atom, the repulsive effect of which is indicated in the changed path of the alpha particle. The small number of such

deflections must indicate that the chance for such contacts is extremely small. This must indicate that relatively little of the total volume of the atom is taken up by the nucleus.

Moseley demonstrated by means of the characteristic X-ray spectra, that each atomic nucleus carries a positive charge, which in most cases is equal to about one-half of the atomic weight of the atom under consideration. The numerical value of this charge is termed the atomic number of the atom. We may look upon the nucleus of the atom of carbon as being made up of three alpha particles, giving a total of twelve protons and six electrons. Sodium may have a nucleus consisting of five alpha particles, three protons, and two electrons. The total positive charge in the nucleus is twenty-three, the total negative charge twelve, and the difference (protons not neutralized by electrons) is eleven, the atomic number of the element. If we periodically arrange the elements in order of their atomic numbers, we shall have practically the periodic table arrangement with the exception of the three pairs of elements, argon and potassium, cobalt and nickel, and tellurium and iodine. These elements do not fit into the table unless they are arranged contrary to the positions indicated by their atomic weights. The work of Moseley and his followers showed that the atomic number arrangement, giving the above mentioned elements their proper periodic positions, was justifiable. The atomic number of argon is eighteen while that of potassium is nineteen, although the atomic weight of argon is greater than that of potassium. The atomic number of cobalt is twenty-seven and that of nickel twenty-eight, although the atomic weight of nickel is less than that of cobalt. Finally, the atomic number of tellurium is fifty-two and that of iodine, fifty-three, although the atomic weight of tellurium is greater than that of iodine. Evidently the atomic number, and not the atomic weight, determines the position of the element in the periodic table.

At the present time our conception of the atom is that of a very small, compact nucleus containing all of the mass of the atom and possessing a definite positive charge. About this nucleus are grouped enough electrons to exactly balance the charge upon it. With sodium this number of electrons is eleven, with carbon six. These electrons are assumed to be arranged in some symmetrical fashion about the nucleus. It is the primary purpose of this paper to consider the various theories regarding this arrangement.

THE KOSSELL THEORY.

Abegg first noted that the sum of the highest electro-positive valence and electro-negative valence of certain elements is in many cases eight. Nitrogen has an electro-negative valence of three in ammonia and an electro-positive valence of five in nitric acid. Sulphur has an electro-negative valence of two in hydrogen sulphide and an electro-positive valence of six in sulphuric acid. Moreover in considering the positive valence of the elements in the second short period of the periodic table, we note that there is a definite increase in going from sodium through chlorine.

Element.	*Positive Valence.*
Na	1
Mg	2
Al	3
Si	4
P	5
S	6
Cl	7

This seems to indicate a definite increment of some sort. Kossell and others looked upon this and other facts as indicating a structure of the type illustrated in Fig. 1. Considering this system, it is to be noted that the two electrons of the helium structure are carried throughout the period (and subsequent periods) and that the addition of an electron to the outer portion of the atom gives the next element in the period. Of course sufficient changes must be made in the nucleus to account for the difference in atomic weights and atomic numbers of the elements.

Apparently the most stable arrangement of the outer electrons is that found in the noble gases, since they hold to their electrons so firmly as to prohibit compound formation. It is likewise obvious that stability in atomic structure tends toward the electronic arrangement of the noble gases. Hence those elements having less than four electrons in their outer orbits may acquire stability by the loss of these electrons. Those elements having four or more electrons in their outer orbits may acquire stability by the gaining of enough electrons to fill out the orbit to eight. The loss of electrons must of course tend to reduce the orbit to zero and make the electron pair of two (the stable helium orbit) the stable outer orbit group. To illustrate: Lithium loses one electron, glucinum two, in order to revert back to the

stable helium outer group, while chlorine may lose seven electrons or may gain one electron to fill up its outer orbit to eight. The loss of the seven electrons takes the outer orbit back to the stability of neon with eight electrons. Sodium loses one electron

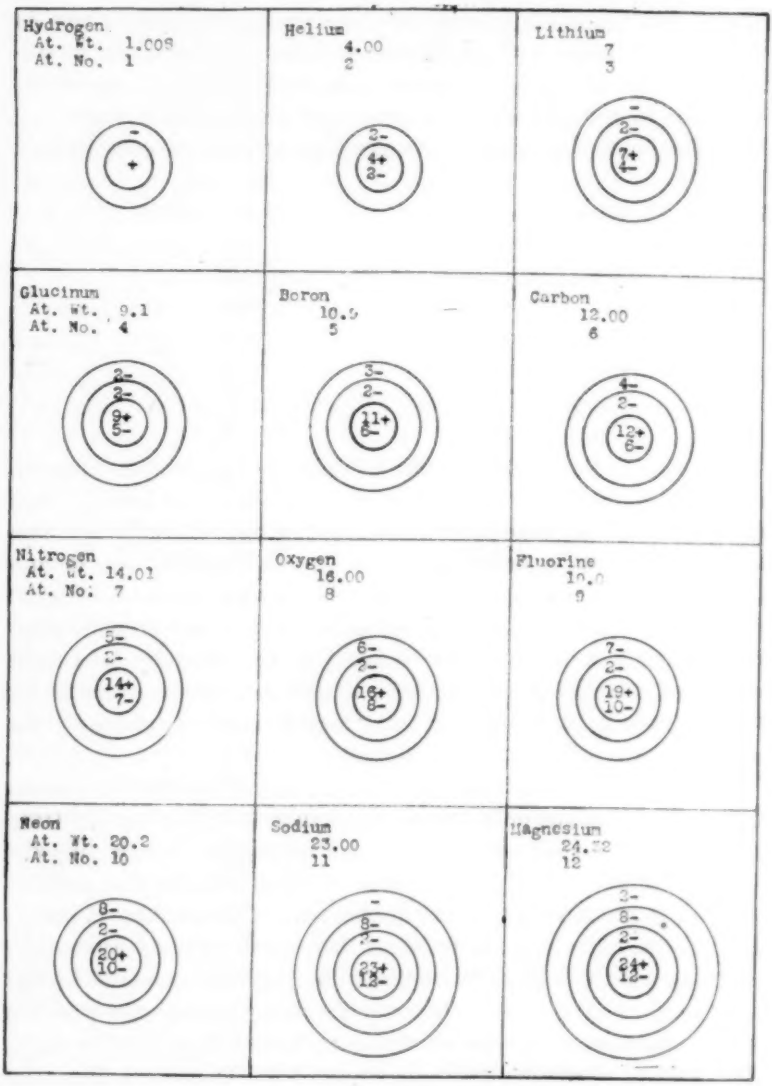


FIG. 1.

The first twelve elements in the periodic system according to the Kossell theory. The dimensions are not relative. The electrons are probably arranged symmetrically about the nucleus.

and magnesium two to revert back to the same type of stability. Apparently this loss or gain of electrons is synonymous with the development of valence and is numerically equal to it. The apparent ability of the element to develop valence is its ability to change to a more stable arrangement of electrons with either two or eight in the outer orbit. (In the case of the more complex atoms, this change may be to an orbit having eighteen or thirty-two electrons.) Those elements having four or fewer electrons in the outer orbit tend to lose electrons, while those having four or more electrons in the outer orbit tend to gain electrons. This action is the result of the tendency to stability in electronic arrangement.

On the basis of the tendency of atoms to lose or gain electrons, the following classification has been proposed.

Elements losing electrons. Most metals belong to this class. Their position in the periodic table makes it easy for a reversion to the noble gas structures to be accomplished.

Elements gaining electrons. Fluorine is the only element belonging to this group.

Elements gaining or losing electrons. The greater portion of the elements belong to this group.

Elements neither gaining nor losing electrons. The noble gases do not gain or lose electrons. They do not enter into chemical combinations.

The Kossell theory is useful in interpreting atomic structure in terms of the periodic system. It also affords a good foundation for the development of the electronic conception of valence. Its shortcomings lie in the fact that it does not satisfy the demands of the physicists due to its inability to properly correllate atomic structure and spectral lines, that it presents only a plane arrangement for the atom, that it makes all valence due to an actual exchange of electrons. However it fits in well with the facts of the periodic table. We should not however make the very common mistake of supposing that the periodic arrangement is the result of this atomic structure system, rather this system is the result of the study of facts associated with the periodic arrangement. This general type of fallacy may be found associated with many theories. The primary worth of this theory is its ability to draw an atomic arrangement which is in keeping with many physical and chemical facts. Table 1 is inserted to illustrate a possible composition for nuclei, and an arrangement of electrons according to the Kossell theory.

TABLE 1.

Element	*At. Wt.*	*At. No.*	*Nucleus*	*Outer Electrons*
H	1.008	1	P	1
He	4.00	2	He	2
Li	6.94	3		
	6	3	HeP_2e	2+1
	7	3	HeP_3e_2	2+1
Be(G1)	9.1	4	He_2Pe	2+2
B	10.9	5		
	10	5	He_2P_2e	2+3
	11	5	$He_2P_3e_2$	2+3
C	12.00	6	He_3	2+4
N	14.01	7	He_3P_2e	2+5
O	16.00	8	He_4	2+6
F	19.00	9	$He_4P_3e_2$	2+7
Ne	20.2	10		
	20	10	He_5	2+8
	22	10	$He_5P_2e_2$	2+8
Na	23.00	11	$He_5P_3e_2$	2+8+1
Mg	24.32	12		
	24	12	He_6	2+8+2
	25	12	He_6Pe	2+8+2
	26	12	$He_6P_2e_2$	2+8+2
Al	27.1	13	$He_6P_3e_2$	2+8+3
Si	28.3	14		
	28	14	He_7	2+8+4
	29	14	He_7Pe	2+8+4
	30	14	$He_7P_2e_2$	2+8+4
P	31.04	15	$He_7P_3e_2$	2+8+5
S	32.06	16	He_8	2+8+6
Cl	35.46	17		
	35	17	$He_8P_3e_2$	2+8+7
	37	17	$He_8P_4e_4$	2+8+7
Argon	39.9	18		
	36	18	He_9	2+8+8
	40	18	He_{10}	2+8+8

P = proton.
He = P_4e_2 = the helium nucleus.
e = electron.
Isotopes are listed wherever they are known to exist.

THE BOHR THEORY.

One great difficulty with the static type of atom is its inability to explain the various lines in the spectrum of an element. Since each element has its own characteristic lines it is highly probable that these lines are characteristic of the structure of the atom. The general and widespread acceptance of the Bohr theory is due quite largely to its ability to correllate the structure of the atom with the lines of the spectra of the elements. In fact the theory is based upon the facts of spectroscopy.

The necessity of motion for the electron in its orbit was early recognized. This motion must be present in order to keep the electron from collapsing on the nucleus, since there must be some attraction between the negative electrons and the positively charged nucleus. According to the classical electro-magnetic

conceptions, an electron rotating about a nucleus should gradually lose energy and eventually make contact with the nucleus. That this does not occur is apparent to every student of atomic structure.

Bohr's assumptions are as follows:

I. An electron revolves in a circular or elliptical orbit about the nucleus of the atom and does not lose energy in so doing. The number of revolutions which the electron makes in the orbit in a unit of time is defined by

$$\omega^2 = \frac{cE}{4\pi^2\mu a^3} \tag{1}$$

where ω = number of revolutions, c = charge on electron, E = charge on the nucleus, μ = mass of electron, a = radius of the orbit.

II. The energy of an electron can vary only discontinuously and for this reason an electron is only at equilibrium in certain orbits having a determinate radius as defined by

$$2a = \frac{n^2h^2}{2\pi^2\mu cE} \tag{2}$$

where h = Planck's constant = 6.7×10^{-27} erg/sec., and n = an integer, 1, 2, 3, etc.

The energy of the electron is defined by

$$W = \frac{2\pi^2\mu c^2E^2}{h^2} \cdot \frac{1}{n^2} \tag{3}$$

III. When an electron moves toward the nucleus, passing from an orbit of longer radius and higher energy content, to an orbit of shorter radius and lower energy content, the energy it loses is emitted in the form of monochromatic light or in other words, in the form of electro-magnetic waves of definite frequencies. The increment in energy is defined by

$$\triangle W = h\upsilon \tag{4}$$

where υ = frequency of light emitted.

If the energy of the orbit from which the electron moves is defined by W_n and the energy into which the electron moves as W_m, then it is obvious that the increment in energy, $\triangle W$, is defined by

$$\triangle W = W_n - W_m \tag{5}$$

and from equation (3) that the increment in energy is

$$\triangle W = \frac{2\pi^2\mu c^2E^2}{h^2} \cdot \left(\frac{1}{n^2} - \frac{1}{m^2}\right) \tag{6}$$

replacing E^2 by Ne (where N is the atomic number) and $\triangle W$ by

$h\upsilon$ (equation 4) the combination becomes

$$\upsilon = \frac{2\pi^2\mu e^2}{h^3} \cdot N^2 \cdot \left(\frac{1}{n^2} - \frac{1}{m^2}\right) \tag{7}$$

and since $\frac{2\pi^2\mu e^2}{h^3}$ is a constant, the equation becomes

$$\upsilon = K \cdot N^2 \left(\frac{1}{n^2} - \frac{1}{m^2}\right) \tag{8}$$

IV. In any one of the orbits the condition of the electron is governed by the classical laws of electro-dynamics.

If (8) is applied to the element hydrogen we have

$$\upsilon = K\ 1^2 \left(\frac{1}{n^2} - \frac{1}{m^2}\right) \tag{9}$$

Now if Bohr's theory is in accordance with the facts of spectroscopy, there should be in the spectrum of hydrogen a series of lines corresponding to this formula. Four such series of lines have been discovered and carefully studied. The Lyman, Balmer, Paschen, and Brackett series correspond respectively to values for m and n as indicated in Table 2.

TABLE 2.

Series	*Region of spectrum*	*n*	*m*
Lyman K	Ultra-violet	1	2, 3, 4, 5, etc.
Balmer L	Visible	2	3, 4, 5, 6, etc.
Paschen M	Infra-red	3	4, 5, 6, 7, etc.
Brackett N	Infra-red	4	5, 6, 7, 8, etc.

In this series the value for the constant k is written R, the Rydberg constant $= 329{,}033.07 \times 10.^{10}$ The calculated values for the series for R are in good agreement with the values derived for k. Moreover the frequencies calculated by means of equation 8 are in good agreement with the observed values.

The nomenclature employed for the designation of these lines is illustrated in Fig. 2. The series for hydrogen in Table 2. It will be noted that the K_ε line corresponds to the transfer of an electron from the L orbit to the K orbit, $K\beta$ from the M orbit to the K orbit, and $K\gamma$ from the N orbit to the K orbit. In other words the K represents the orbit into which the electron is transferred, and the Greek letter the orbit from which it came. $L\beta$ then will correspond to the transfer of an electron from the N orbit to the L orbit.

It must not be assumed that the energy emitted in the above

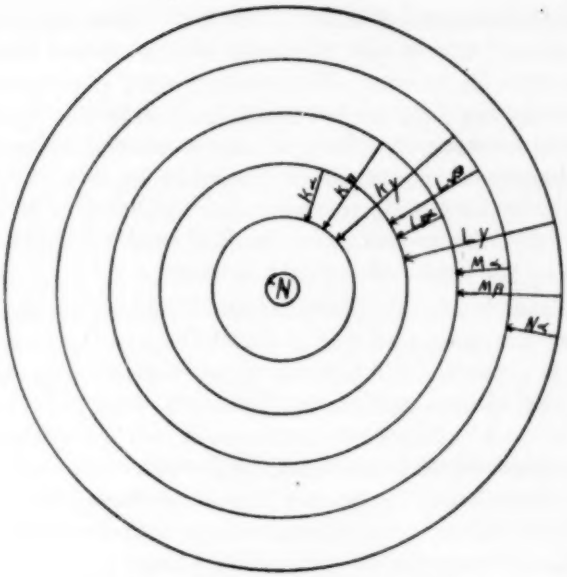


FIG. 2.—THE BOHR ATOM.
Illustrating the relation between the lines in the spectra of hydrogen and the orbits of the Bohr atom.

system of transferrals is the same for all cases. Fig. 3 represents the relative energy contents of the various orbits for an element such as hydrogen. It is quite obvious that the energy released during the transfer of an electron from the M to the L orbit is less than that from L to K.

If the spectrum for helium is considered, equation 8 becomes

$$\vartheta = R\,2^2\left(\frac{1}{n^2} - \frac{1}{m^2}\right) \tag{10}$$

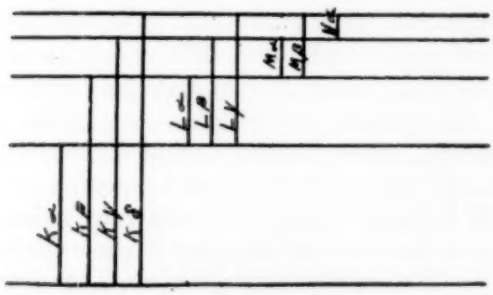


FIG. 3.—ENERGY LEVELS.
Showing the comparative amounts of energy emitted in the production of the spectra of hydrogen.

since the atomic number of helium is two. Here again we have an agreement between the calculated and observed frequencies in the spectra for helium. There is of course an increase (over hydrogen) in the frequencies emitted by helium. Earlier disagreements between the observed and computed values for the lines of helium have since been proved to be due to a slightly different value for the Rydberg constant for helium. Bohr's prediction of this different value for the R of helium has had no little influence on the establishment of the theory.

As the atomic number increases, the frequency of the emitted light wave increases, resulting in the shifting of the series, whose in value is 1, toward and into the X-ray region. This must be, since as the energy emitted increases, the frequency increases. (See equation 4.) Moseley's work on the position of the element in the periodic series established the law which bears his name. This law states that: the square root of the frequency of the X-ray wave is directly proportional to the atomic number. This is the same statement as that derived from equation 10 since R and $\left(\frac{1}{n^2}-\frac{1}{m^2}\right)$ are the same for one line, hence they go into the formation of one constant giving

(11) $$\sqrt{\nu} \doteq N$$

Needless to say that this is a very strong proof of the validity of Bohr's assumptions.

Another very important factor in the establishing of the Bohr theory was its ability to predict that Hafnium would be found associated with Zirconium rather than with the rare earth elements. Hafnium, which occurs in appreciable amounts, was not discovered until Bohr pointed out the probability of its association with Zirconium. It is beyond the scope of this paper to go into the details upon which the prediction was based.

It is the purpose of the writer to next discuss the correllation of the Bohr theory with the periodic arrangement of the elements. Beginning with hydrogen we find that there are twenty-nine lines known for the Balmer stellar spectra, indicating the possibility of at least twenty-nine orbits in which the single electron may be located (not however at the same time.) The most stable condition of the electron in the hydrogen atom is in orbit K. Its location in a larger orbit or in an elliptical one reduces the nuclear attraction and allows the atom to eventually reach the state where the electron will be free from the attrac-

tive force exerted by the nucleus. This is the state which we call ionization. Again the electron may get so far away from the nucleus that the attractive force is very small. This occurs when the electron is in an elliptical orbit; the outer end of which is far from the nucleus of the atom. Obviously the electron will spend most of its period of rotation in the outer part of its orbit, since its velocity there is very much less than when in close to the nucleus. The difference in velocity results in a difference in mass, thus imparting a tumbling motion to the atom.

The first period of the periodic table has been postulated as follows:

Hydrogen. See above.

Helium. There are two states for helium each having a definite structure.

Parhelium. Two electrons describing orbits about the nucleus at 120° angle to one another. The orbits are circular. This is the more stable state.

Orthohelium. One orbit outside the other.

Lithium. Two orbits of stable helium. These are continued throughout the entire periodic system. One thin elliptical orbit outside these two.

Glucinum. Two elliptical orbits. (Two helium orbits not included from this point on.)

Boron. Three elliptical orbits.

Carbon. Four elliptical orbits.

In the above three elements the electrons are in similar types of orbits, symmetrically arranged. The electrons reach the position nearest the nucleus at equal intervals, and are equally spaced in positions in the orbits.

Nitrogen. The fifth electron (exclusive of the helium pair) moves in a circular and larger orbit. It lies outside the two electron orbit, although orbits 3, 4, 5, 6 (counting two electrons of helium) extend beyond it at their extreme limits.

Oxygen. One more orbit similar to nitrogen.

Fluorine. One more orbit similar to oxygen.

Neon. The tenth electron (counting helium pair) is in a circular orbit. The entire system of orbits is arranged symmetrically and all are located close in to the nucleus so that the maximum force is exerted upon each electron by the nucleus.

It is obvious that this system is very similar to that suggested by Kossell. The addition of the electrons and the proper adjustment of the nuclear charge create the succeeding elements.

Bohr adds no additional information regarding the nuclei of the atom. The structure of the electronic orbits for the elements of higher atomic numbers adds a problem of great difficulty due to the large numbers of variables with which the investigator must deal. In addition there is the factor of repulsion of the electrons upon one another.

The singular ability of the Bohr atom to fit into the periodic table has made its acceptance by the chemist almost an assured fact. There are many factors in the Bohr theory which do not yield so readily to analysis. Sommerfeld has modified the theory to meet the demands imposed upon it by newly discovered facts, but even his genius has been unable to explain everything in terms of the Bohr theory. We must look at the Bohr theory as explaining many but not all facts regarding the structure of the atom. Several shortcomings are listed below.

(1). The theory does not account for the stability of the group of eight electrons.

(2). There are more energy levels in the atom than can be accounted for even with the modified Bohr theory.

(3). The theory does not coincide with the electro-magnetic theory, especially with the emission of energy concepts.

(4). Electrons appear to rotate in orbits, the centers or focii of which are not the nucleus of the atom.

(5). There are several other minor discrepancies.

In conclusion we may state that the Bohr atom offers a very fine picture of the structure of the atom. Probably a modification of the Bohr atom will be the finally accepted view.

(The Wave Theory of Schroedinger and the Lewis-Langmuir Theory will be discussed in the April number.)

ACCESSORY NON-EDUCATIONAL PROBLEMS AT TEACHERS COLLEGE.

Some minor material facts might serve to indicate some of the accessory non-educational problems. During the last year the total budget exceeded $4,000,000; we served 1,375,000 meals, consuming 200,000 pounds of meat, 55,000 pounds of fish, and 50,000 pounds of poultry; we made 175,000 outgoing telephone calls; we used 15,000 tons of coal, 1,075,000 two-cent stamps, 2,225,000 sheets of paper, 5,300,000 sheets of mimeograph paper, 45,000 pencils, 2,000,000 paper towels, 100,000 drinking cups, 25,000 pounds of soap; we employed for full time 142 clerical workers, 90 janitors and elevator operators, 64 maids, 27 engineers, 14 carpenters, 8 painters, 5 electricians, and 10 accountants.—Dean Wm. F. Russell.

MATHEMATICS IN INDUSTRY.

By C. J. Leonard,

Cass Technical High School, Detroit, Mich.

Mathematics the oldest, and the queen of all the sciences, has recently become one of the chief subjects of contention among the makers of high school curricula. Even the high school mathematics teachers have not been in agreement on the aims and methods in mathematics, or the content to be taught.

One thought on the subject of mathematics that I believe is ever present in the minds of teachers and administrators is the so-called practical or utilitarian value of the subject. Yet I wonder if many of them ever stopped to make a thorough study of how mathematics beyond arithmetic is used, and who uses it, and what percent of our students will ever use it, and what portions of it they will use.

It is the purpose of this discussion to point out in as definite a manner as possible, how high school mathematics is used by men in the industry. While considering this subject it is not my purpose to argue that this is the sole justification for mathematics, nor even the chief justification for it. I wish to refer to an article "Mathematics in the Training for Citizenship" by David Eugene Smith, published in the last year book of the National Council of Teachers of Mathematics, as pointing out the real higher motives for teaching mathematics.

Whatever may be said of mathematics in industry may have no part to play in the training of students for the professions or the business world, but we must keep in mind the number of students going into industry. One industry alone in our city of Detroit employs over 100,000 men. The latest available statistics of the Federal Bureau of Education point out that only 40 percent of the students entering high school graduate, and only 52 percent of the graduates go on to college, leaving about 79 percent of the students entering high school who do not enter college. An ever increasing number of these students are going into the big industries. Even some of the students who enter college are going into the industries in none too high a capacity. Therefore the possibilities of mathematics in industry should be taken into account in planning courses for these students.

Boys not planning on going on to college are asking the question "Why study a subject so hard and dry as mathematics?" If they cannot be interested by the values of mathematics such

as pointed out by Mr. Smith, it seems that the teacher should have another point on which to appeal to them. I know that the average boy will not be satisfied if he is merely told that he has to have mathematics to get along satisfactorily in the industries. He needs to be told more definitely what high school mathematics can do for him in industry. Even our evening school students of aeronautics can not be interested in mathematics when they first enroll in aeronautics, but as soon as they begin to study aerodynamics then they begin straggling into the mathematics class of their own accord.

It is not an easy matter for the teacher to find out how mathematics is used in the industries. If we ask the man in the factory we soon find that industry is very highly specialized. I know of one man who worked for years in the Ford factory making the clips that go on the back of the buttons of the upholstery. It is not an uncommon joke to hear of some man who thinks that he has been promoted because he has been changed from tightening nut number seven to the task of tightening nut number twelve, on the assembly line. Even the engineers and research men are specialized. I know of one man who has worked for two years at the General Motors Research Laboratory on headlights only. These men are not prepared by virtue of their experience to throw much light upon the subject. Their training might lead to opinions like the opinions of the seven blind men who went to see the elephant.

If we search the books on practical or applied mathematics we seem to encounter two extremes. Some of the books are so technical, that in order to understand the technical part the student would have to have a training that would have given him more mathematics than the books pretend to give. Other books seem to be no different from the usual mathematics books except on the front cover.

In studying and planning for a mathematics course for students going into industry it seemed axiomatic to me that students would be far more interested in problems involving actual shop conditions. The only thing then was to find the problems that would come up to these specifications and also convey some technical information if possible, and certainly furnish the student a training that would prepare him mathematically to go to the limit in industry. I have seen students with only a high school training outstrip their high school teachers as far as salary is concerned. I soon realized that such problems must be real and

genuine and must avoid all attempts to hitch an ordinary problem onto a milling machine when it does not belong there. In my search for problems and material I did considerable consultation with men from many phases of industry from the production man to the engineer and research man, and received the hearty cooperation of the shop and drawing teacher of our school.

My greatest source of information as well as inspiration has come from the men of our evening school. They are the men who are seeking and winning advancement through technical and mathematical study. We have on the average 500 to 800 men in our evening school studying mathematics beyond arithmetic. These men are urged to bring in any problems they may be having difficulty with in their daily work. We get a good response to these requests, and thereby learn more perhaps of how mathematics problems present themselves than could possibly be learned by working in one narrow line of industry.

The mathematics teachers have cooperated with me 100 percent in collecting and solving these problems. They involve almost every principle of mathematics and mechanics known to the average mathematics teacher. It is frequently necessary to hold consultations over some of the problems thus presented. This phase of our work is most interesting, for we are learning and better preparing ourselves to present a brand of mathematics that will appeal by its own content to the student who is looking for what he calls a practical course. I will present shortly a few of the problems that have been brought in, all of which can be solved by high school mathematics, and none of which involves detailed knowledge of technical conditions. This small assortment of problems I have here will show I believe that there is very little of the usual high school mathematics that can be left out and still leave enough to solve even this list of problems.

Before proceeding to present these problems I want to dispose of an argument frequently offered by high school students on why they should not study mathematics, or at least on why they should not study it very hard. Some one in class always knows of some one in some factory who is getting along well enough and does not know much mathematics. I am not even suggesting that the production man has any direct need for high school mathematics, if he is going to always remain a production man. But the automatic machines are rapidly replacing the production man, and if he wants to safeguard his future it will be necessary for him to

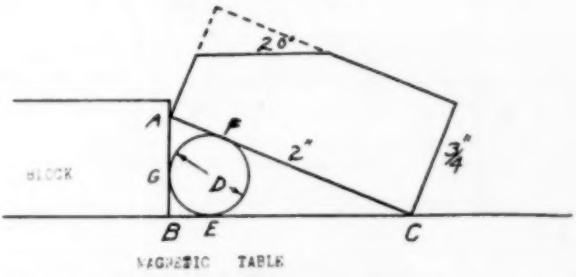
prepare. Even some of the men who are classed as electricians and tool makers seem to find no use for high school mathematics or perhaps it would be better to say they seem to be able to get along without it. But there are different kinds of electricians, tool makers, armature winders, etc. The men who rewind automobile starters and generators call themselves armature winders, although it takes them only a few hours to learn their trade. But the men who can rewind an armature to change its voltage, or speed, according to a specified plan did not learn their trade over night, and *they* do not say that they have no need for mathematics. In the machine shop there are operations of skill, and also operations calling for computation and layout work. An example of skill is shown by a cylinder and a bushing turned down to such accurate dimensions that they fit together smoothly and without play. No considerable knowledge is required to make these, but their construction requires great skill and accuracy. An operation calling for technical knowledge and computation is the laying out of a bevel gear. What really happens in a machine shop is that a foreman has to know his men and assign the jobs accordingly. If a job requires much computation there are a limited number of men who can do the job. Other men get the more routine jobs.

I have made special inquiry of my present evening school classes as to what they think of the possibilities of men winning advancement in the shop through technical training. Almost without exception they tell me that they feel that there is plenty of opportunity. They say that there is a shortage of well-trained men, and the men with the poorer training are the first to be laid off. Some of the men seem to think that there is not sufficient difference of pay between the well-trained man and the poorly trained man. But let me point out that if it costs $100.00 a month to live, and one man gets $125.00 a month and another $150.00, one has twice the money for leisure and savings that the other has. It seems to me that the plans for the training of students for positions in the industries will be largely affected by what kind of men we want them to be after they have had a little experience in the industry. I personally know of men who have advanced from the ranks to the engineering department or head electrician, largely through their training in the evening school. There is a tendency to assign minor engineering problems, especially on tool design to men in the shop. Here a combination of knowledge of shop conditions, mathematics, and mechanics is

required. The man who can do this kind of work is in line for an opportunity to prove his worth.

These evening school men have also given me one of my strongest arguments in favor of a substantial mathematics course. They tell me that they can learn much about the dynamo, the lathe or the milling machine from their job, but mathematics is the one and only thing that they cannot learn in the shop. They usually go through life with the mathematical training they get in school. It is true of course that if they get a good mathematical training in school they can add to their experience in the computations they have to do in the shop.

I will now present an assortment of problems that have been brought in by men of the industry. These problems can all be solved by the methods of high school mathematics, and do not involve detailed technical knowledge. Such problems should show to the technically minded student in language which he will understand that he may have need for all the mathematics he can get. I trust that these few problems and the mathematical principles they involve will be of interest to the readers of SCHOOL SCIENCE AND MATHEMATICS.



Required to cut a rectangular block forming a surface at a 20° angle with the top of the block.

The block to be cut is held on a magnetic table by means of another rectangular block and a cylinder of diameter D. The upper edge is then ground off in a plane parallel to the magnetic table. Find the diameter of the cylinder.

SOLUTION.

$\angle C = 20°$

$AB = 2 \sin 20° = 0.6840$

$BC = 2 \cos 20° = 1.8794$

$AG = AF,\ CE = CF$

$\therefore AB + BC - AC = GB + BE$

$GB + BE = 1.8794 + 0.6840 - 2 = 0.5634$

$GB + BE = D = 0.5634$

KNOWLEDGE REQUIRED

If $2 \angle$s have their sides parallel right side to right side and left side to left side they are equal.

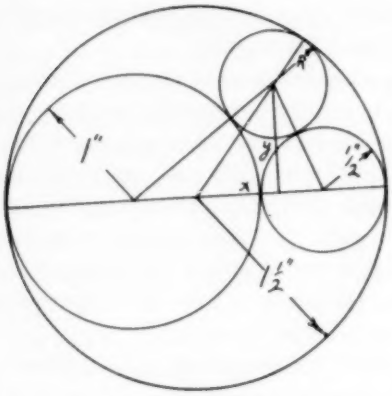
Right triangulation.

Two tangents to a circle are equal.

A radius is perpendicular to the tangent drawn to the point of tangency.

GB = BE = radius of the cylinder.

A 2″ spur gear and a 1″ spur gear are to run separately inside a 3″ internal gear. Find the radius of a third spur gear that will slide in beside the others to form a locking device.



SOLUTION.

Connect All Centers.

$x^2+y^2=(1\frac{1}{2}-R)^2$

$(1-x)^2+y^2=(\frac{1}{2}+R)^2$

$(\frac{1}{2}+x)^2+y^2=(1+R)^2$

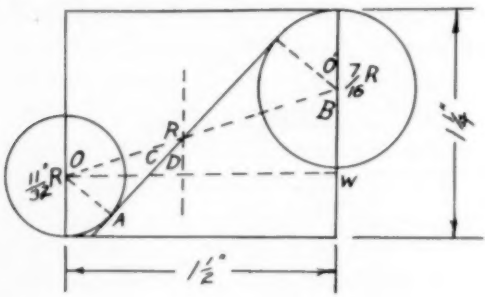
$R=\frac{3}{7}''$

KNOWLEDGE REQUIRED.

The line of centers passes through the point of contact.

Pythagorean Theorem.

Solution of Simultaneous Quadratic Equations.



Required to Find $\angle A$.

SOLUTION.

$O'W=1\frac{1}{4}-(\frac{11}{32}+\frac{7}{16})=\frac{5}{32}$

$OO'=\sqrt{(1\frac{1}{2})^2+(\frac{5}{32})^2}=1.5715$

$\frac{OR}{O'R}=\frac{OR}{1.5715-OR}=\frac{\frac{11}{32}}{\frac{7}{16}}=\frac{11}{14}$

$14\,OR=11(1.5715-OR)$

$OR=0.69146$

$\text{Sin } C=\frac{\frac{11}{32}}{0.69146}$

$\angle C=29°48'41''$

$\text{Tan } B=\frac{1\frac{1}{2}}{\frac{15}{32}}$

$\angle B=72°38'46''$

$\angle D=\angle B-\angle C=42°50'5''$

$\angle A=90°-\angle D=47°9'55''$

KNOWLEDGE REQUIRED.

Pythagorean Theorem.

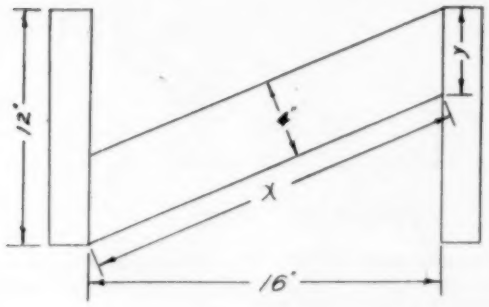
The triangles are similar. The sides of similar triangles are in proportion.

Clearing an equation of fractions when one denominator is a polynomial. Multiplication of a polynomial by a monomial.

Triangulation and Complex Fraction.

If two parallel lines are cut by a transversal the corresponding angles are equal.

The sum of the acute angles of a right triangle is 90°.



FIND X.	KNOWLEDGE REQUIRED.
$\frac{x}{16}=\frac{y}{4}$	Similar Triangles.
$4x=16y$	
$x=4y$	
$x^2=256+(12-y)^2$	Pythagorean Theorem.
$x^2=256+144-24y+y^2$	Square of a Binomial.
$16y^2=400-24y+y^2$	Substitute 4y for x.
$15y^2+24y=400$	Quadratic Equation.
$y=\frac{-24\pm\sqrt{576+24000}}{30}$	
$y=4.4257$	
$x=17.703$	

The following formula is published in a pamphlet entitled "Rough Turning with Special Reference to the Steel Cut" by H. J. French and T. G. Digges, published by the American Society of Mechanical Engineers.

$$V=\frac{K\left[1-\frac{8}{7(32r)}\right]}{F^{\frac{3}{4}}+\frac{2.12}{5+32r}\left(\frac{48}{32r}D\right)^{\frac{9}{16}}+0.06\sqrt{32r}+\frac{0.8(32r)}{6(32r)+48D}}$$

V = Cutting speed for selected tool life in feet per minute.
F = Feed in inches per revolution.
D = Depth of cut in inches.
r = radius of nose of tool in inches.

The tool maker had no difficulty in solving this formula except the part $F^{\frac{3}{4}}+\frac{2.12}{5+32r}$ which reduced to

$0.028^{0.6356}$

$\log 0.028=\bar{2}.44716$

$\bar{2}.44716\times 0.6356$ gave the difficulty since he must derive a result with an integral characteristic.

$\bar{2}.44716=-1.55284$

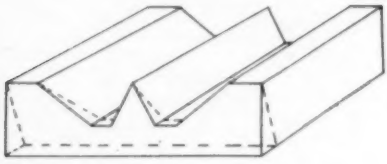
$-1.55284\times 0.6356=-0.98699=\bar{1}.01301$

$\therefore 0.028^{0.6356}=0.10304.$

A very thorough knowledge of logarithms and positive and negative numbers is required for this problem.

Find the angle at the point on the square end, to make 45° on the point after the front face is cut back to give a clearance of 15°.

By drawing the portion of the center ridge cut off we have a pyramid, one side of which is perpendicular to the base. This side and the opposite



FORMING TOOL

side make a dihedral angle of 15°. The opposite side has a vertex angle of 45°. Find the vertex angle on the side perpendicular to the base. Let some convenient line equal one inch.

PILE OF PIPES

I present this problem more as a matter of interest, yet it shows how accurate mathematical thinking is necessary for correct conclusion in relatively simple things.

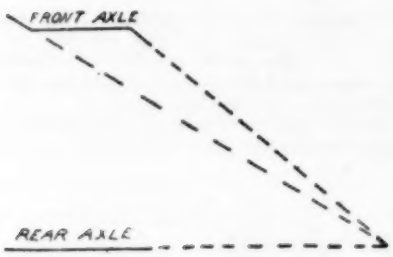
One of my evening school men said he got the laugh at the shop because he told them he could compute the number of pipes piled in triangular shape. He told them there are 6 pipes in the bottom row and 6 rows, therefore $\frac{6\times 6}{2}=18$, but on actual count there are 21. He wanted to know why his method was wrong.

Of course progressions would work nicely but he hadn't had progressions, so I told him to consider this as a trapezoid, with 6 units in the bottom row and 1 unit in the top row then the formula $6\frac{6+1}{2}=21$, the correct answer. A general formula can be written out in the same manner.

Two simple questions that have come to me indicate the usefulness of the handbook and also point out that a good training in mathematics is necessary to get satisfactory service from the handbook.

The first man wanted to know how far apart he could place supports for a given beam, carrying a given load. He found the formula for the load a beam would carry when the dimensions of the beam were given, but he could not solve the equation when the unknown was in the second member.

The second man was trying to find the volume of a steel sphere flattened on one side. He found a formula but he got the formula for a spherical sector instead of a spherical segment. He had not studied solid geometry. However he had the good sense to know that his answer was not reasonable.



Ideal alignment of automobile wheels in making a right turn.
Distance between king pins, 53″.
Wheel base, 120″.

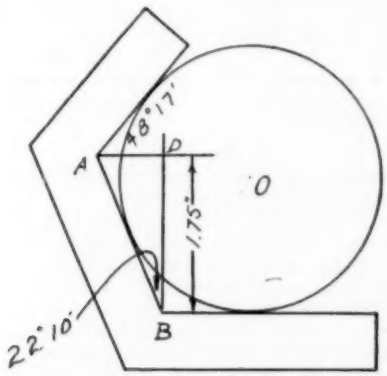
Find the angle the right wheel should make when the left wheel makes a 20° turn. The center lines of the two front spindles should meet on the center line of the rear axle.

The problem is easily solved by right triangulation.

Front Axle and Steering Mechanism of Automobile.
Distance between King Pins, 53″.
Length of Spindle Arm, 8″.
Length of Tie Rod, 49.55″.
Wheel Base, 120″.

When the left front wheel turns 20° what will the right front wheel actually turn?

It is seen that when the car is headed straight forward the wheels are connected together through a trapezoid, but when the wheels are turned the trapezoid is changed into a trapezium. The four sides are given and the angle at the left king pin can be easily computed. The diagonal opposite this side can be found by the law of cosines. Then on the opposite side of this diagonal is a triangle having three sides given. The angle at the right spindle can then be computed, and hence the actual angle of turning of the right wheel.

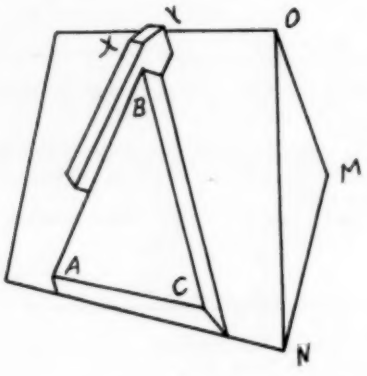


Required to find the plug gage that will check the measurements above.

The student must recognize the fact that the center of the circle lies on the bisectors of two angles. Then if he finds the line AB by right triangulation, he will have two angles and the included side of triangle AOB.

If he knows that a tangent is perpendicular to the radius drawn to the point of tangency he will know that the altitude of the triangle is the radius of the circle. If he does not know the formula for the altitude of a triangle when two angles and the included side are given, he will have a problem rather difficult for the average student.

To fully check the dimensions a smaller plug should be placed in angle A to become tangent to the line BD. This forms another problem similar to the first.



For the accurate grinding of threading tools the jig shown above was devised. The tool to be ground is placed first on one side of the triangular piece ABC, then on the other side and each time ground off in a plane parallel to the base of the jig. If the point of the threading tool is to have an angle of 60° with 15° clearance, find ∠ABC and ∠MNO.

SOLUTION.

∠A = Angle at the point on the center of plane of the tool.

∠A = 75°.

∠C = 30°.

To find ∠ONM pass a plane through N parallel to the side of the solid ABC. The angle at N in this new plane is 30°.

The angle at N on the sloping face of the jig is 15°.

Then we have a pyramid with two angles at the vertex given.

Let ON = 1 and find OM.

KNOWLEDGE REQUIRED.

Sides || right side to right side, etc.

Sum of the angles of a triangle is 180°.

A device of solid geometry.

Side parallel to centerline of tool, etc.

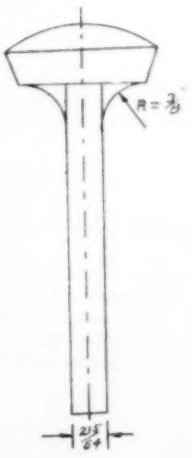
90° − ∠C.

The student will need to have practice in visualizing and analyzing to finish this problem.

Required to find the length of straight rod $\frac{215}{64}$" in diameter from which this valve can be forged.

The man bringing in this problem could find the volume of a cylinder. He found in his handbook formulas for the volume of the segment of a sphere and the volume of a frustrum of a cone. These formulas involved exponents and radicals. He could not find the volume of the fillet. However in his handbook he found the formula for the area and center of gravity of a spandrel but could not put the two together for the volume. This problem could also be solved nicely by calculus.

The same type of problem was recently brought in by a man trying to find the volume of a die for making kettles.



In conclusion I wish to state that these problems I have presented show that practically all high school mathematics is involved. They do not arise from obscure conditions but from common ones. They are well suited for students in technical high schools, and I believe useful as supplementary problems in other schools. While some of these problems will be analyzed by only the better students they provide well for individual differences by furnishing the weaker students drill in manipulation after they have been analyzed.

These applications lead me to the following conclusions.

1. Students going into technical work need all the mathematics ordinarily given for college entrance and more in addition.

2. Students not going to college should have a general mathematical training, no one line of work seems to confine itself to one line of mathematics.

3. Some of the weaker students going through high school are not mathematically prepared for success in the industries.

4. The hand book does not remove the necessities of learning the principles of mathematics.

5. The two things most commonly met are the formula and the triangle. The formula requires all the devices of algebra and logarithms, and the triangle calls for a knowledge of all the facts of geometry and trigonometry.

6. Students who cannot do arithmetic with facility cannot do problems enough of this type to get sufficient drill.

7. To the man in the shop a good knowledge of arithmetic is worth far more than a meager knowledge of arithmetic and algebra.

8. Men in the industry who cannot do arithmetic, simple algebra and trigonometry, readily, do not have mathematics enough to do them much good.

9. Mathematics is necessary as a matter of preparedness for problems that are bound to spring up without warning.

It was Abraham Lincoln who said "I will study and prepare and some day my chance will come," and that holds good as far as mathematics in industry is concerned.

WISDOM.

The only way to keep men from agitating against grievances is to remove the grievances. An unwillingness even to discuss these matters produces only dissatisfaction and gives comfort to the extreme elements of our country, which endeavor to stir up governments to embark upon a course of retaliation and repression. The seed of revolution is repression. The remedy for these things must not be negative in character. It must be constructive. It must comprehend that the antidote for the unrest which manifests itself is not suppression, but a deep consideration of the wrongs that beset our national life and the application of a remedy.—*Woodrow Wilson.*

AN ARTIFICIAL ANT NEST AS A PROJECT IN THE TEACHING OF BIOLOGY.

By D. F. Miller,

Department of Zoology and Entomology, the Ohio State University, Columbus.

To the average individual the word "ant" usually suggests a pest, but to the teacher of biology it can be made to mean a way of imparting a great amount of information about insects in general and about their social life in particular. One frequently hears the complaint from teachers of biology, nature study, zoology and entomology, that at about the time when the fall term of school gets well under way the outdoor life and sources of material are cut off by the approach of winter. To a certain extent this may be true though animals which do not migrate may be found throughout the year.

A convenient, extremely interesting and highly instructive substitute, however, can be found in the construction and maintenance of an artificial ant nest. The nest can be used to show the normal activities and social life of these fascinating little creatures at all times, something which cannot be observed out of doors since the disturbance caused by investigating their natural homes upsets their normal behavior.

The teacher will find his students more than eager to construct such a nest, capture the colony and install it in its new quarters. In fact he may have to insist upon their not spending too much time at the nest at the expense of other less interesting duties.

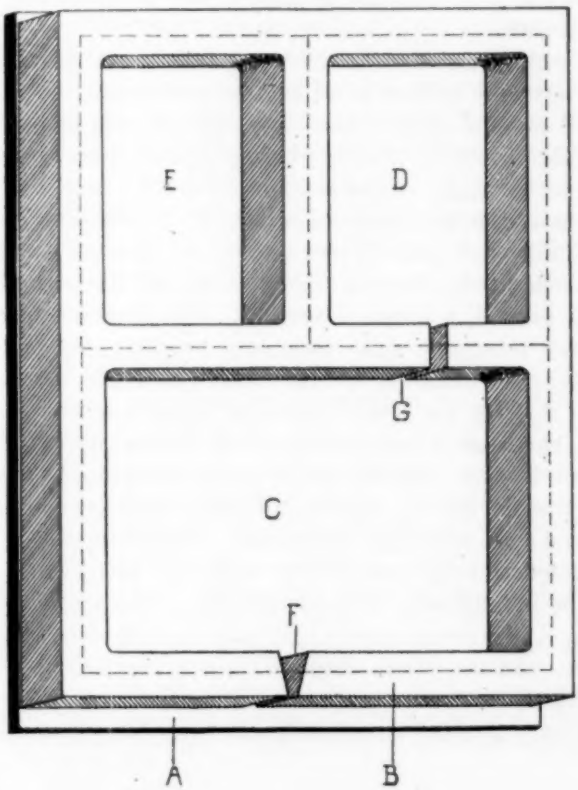
Construction of the Nest.

A number of different kinds of artificial nests have been described by workers with ants. The particular form used is of little consequence as long as the following points are kept in mind in its construction: (a) it must be so constructed that it can be tightly closed at first until the newly introduced colony has accepted its new home, which it will usually do in a few days; (b) it should have a means for keeping one side or corner of the nest moist; (c) it should be partly of glass so as to make observations easy.

The accompanying diagram shows a nest which was constructed and which housed a colony of ants for over a year. A— is a pane of ordinary window glass (a smooth board or piece of slate would be equally good); B— is a wall made by sawing out a piece of plaster-filled wall board. This wall is best when one

inch or less in height so that a hand lens can be used later in watching the inhabitants. It should be stuck to the lower plate of glass by a thin coat of glue or paraffin. C— and D— are chambers into which the colony is introduced and E— is a container for a flat piece of sponge (cloth would do) which is kept saturated with water at all times. The openings F— and G— may be plugged with cotton if not used. If each of the chambers is covered over at the top with a separate piece of glass, as indicated by the dotted lines, it makes possible the opening of one part of the nest at a time without disturbing the rest.

I would suggest that a nest of this type molded out of cement, like the poured foundation of a house, would be still better. By pouring the bottom also, the lower plate of glass could be eliminated. Then, before the cement sets, press the upper glass cover plates down firmly so as to make a perfect union without cracks. If the glass covers do not fit closely on the nest, narrow strips of felt or heavy cloth may be glued along the upper edge of the walls. This will make an ant tight union.



It does not require much ingenuity on the part of teacher or pupils to devise other types of nests or variations from this one. This simple design is suggested as a beginning and its use has proved that it is satisfactory.

Colonizing the Nest.

The ant colony should be located when the nest is finished. Rather small forms are probably best and easiest to handle. The colony must be dug up quickly and a part of it placed in a quart fruit jar. It is very essential that the captives consist of one or more queens and a large number of workers and some eggs or young (larvae and pupae). If the young are present the workers will soon become content in their new quarters. If the fruit jar and its contents are first chilled by placing in a refrigerator for a short time they may be dumped out into the new nest without loosing very many ants. The nest should be watched closely for an hour or two for leaks, which the ants will find if they exist at all. Some ants prefer dark and will settle down more quickly if the nest is kept covered at first. Do not put much dirt or debris in the nest with the ants as it only obscures the view of their activites.

If the walls are shallow it will be possible to watch their activities at any time with a hand lens or microscope. You will be surprised at how little notice they take of you after they are thoroughly adjusted. The egg laying of the queen, the care and sorting out of eggs, larvae and pupae by the workers, and all feeding activities can be easily watched. In one of my nests the queen finally died and I had the unusual pleasure of watching, under a hand lens, the egg laying of one of the workers, which does not occur if a queen is present. The workers were unable to requeen their nest since their eggs produce only males.

By using for chamber C— a cover which has several round holes in it, food and small drops of water may be introduced easily. The kind of food preferred will depend upon the kind of ants and is best determined by experimenting. Try sugar, honey, insects freshly killed, raw and cooked meat, and the pulverized yolk of a hard boiled egg. They are usually fond of honey, meat and egg yolk, and the latter can be placed in a bottle and kept indefinitely without spoiling. Don't give them too much food but use a variety. It may be necessary to clean out the room you use for feeding. This may be done by plugging up the doorway to the room containing the nest. It will never be necessary to clean the chamber in which they have their eggs

and young as they will do that better than you can. After several months of confinement I opened up one of my nests and it was then never necessary to clean any of it as the ants carried all refuse to the edge of the table and dumped it over. But some scouting ants fell from the table and were unable to find their way back, diminishing the colony, but they never attempted to remove the nest.

Placing an electric light or heater several inches above the nest so as to warm the cover, often causes the workers to place the eggs up against the under surface of the glass, duplicating the reaction which causes so many to be found on the under surface of a flat stone which has been lying in the sun. A terrific battle can be started by adding a few strange ants to the colony after it had been definitely established. There is no hope for the intruder. This demonstrates the group protection response of the nest.

Nearly always a careful examination of the nest and its members will show the presence of numerous myrmecophiles, parasites and scavengers, which live along with the ants or upon them. These little creatures are of but little less interest than the ants themselves.

I do not know of a more interesting or more instructive project in biology than one or more of these nests. Several different species could be run for comparison. It contains sufficient interest and sufficient possibilities to fascinate students from the grades to graduates in college. It is the answer to one of the serious complaints of the biology teacher and is infinitely more instructive than much of the expensive preserved laboratory material so often used.

A NEW CURRENT TRANSFORMER.

A miniature transformer for use with a one-ampere range A. C. ammeter was recently developed in the laboratories of the Weston Electrical Instrument Corporation. This remarkable little instrument makes possible the measurement of currents ranging from 0.2 to 200 ampheres with an accuracy of one per cent. It has four self-contained primary ranges of 2, 5, 10 and 20 amperes controlled by a switch on the top of the instrument. The 200, 100 and 50 ampere ranges are made by passing the conductor one, two and four times thru a hole in the transformer. For an outlay of about forty dollars for ammeter and transformer an instrument is available for all the ranges needed in the ordinary work of the school laboratory.

SOURCES OF ENERGY.

By A. A. KNOWLTON,

Reed College, Portland, Ore.

The earth is a great solar engine of low efficiency. As such it receives radiant energy from the sun in enormous quantities, utilizes a small fraction of this energy in its operation and, almost at once, reradiates all except the minute fraction which is fixed by the action of green plants.

The realization that life and the conditions which make life possible are directly dependent upon sunlight is older than the beginnings of history. In regions as widely separated as Asia Minor and Mexico the sun was an object of worship, personified under names which may be freely translated as "The Giver of Life." To primitive men the realization that the rising of the sun is the most important event of any day came easily. The event still retains its importance but recognition of the fact is difficult for us because our belief in the constancy of nature excludes any thought that it may possibly not take place. So long as the sun was looked upon as a god having very man-like qualities one could not feel at all sure that the daily return would occur, hence its consummation was an occasion for rejoicing; a gift of the god, requiring suitable acknowledgment lest it fail the next day. A portion of an old hymn of the Vedas runs as follows:

Will the sun rise again? Will our old friend the Dawn come back again? Will the powers of Darkness be conquered by the God of Light?

Even though one has a justifiable suspicion that these questions in the Vedic ritual were strictly rhetorical it is still clear that they had survived from a time when men asked them in deadly earnestness—and more deadly fear.

Greek mythology retained the old sun myths in highly developed and poetic form but some Greeks had glimpses of a nature which was something other than a congress of deities. Anaxagoras (500 B. C.) seems to have been the first philosopher who definitely transferred the question, What is the sun? from the domain of theology to that of physics. His hypothesis, that the sun was a white hot ball of iron, had as much to recommend it as any suggested until within the last hundred years

[1]Dr. Knowlton is Professor of Physics at Reed College. He is the author of *Physics for College Students* (Mcgraw-Hill), a beautifully written introductory textbook which treats Physics from the humanistic standpoint.—D. R.

and was much less far fetched than some which had the support of noted men of science in comparatively recent times. It is less than a century and a half since one of the greatest of astronomers, Sir William Herschel, could accept and actively support the hypothesis that the sun was a habitable planet, similar to the earth but surrounded by a luminous atmosphere. Sunspots were supposed to be rifts in this glowing envelope through which one might catch occasional glimpses of the surface, and a further assumption, hardly within the realm of science, located the home of the blest on this effulgent planet.

If one asks how it was possible that so keen an observer and so forceful a thinker as Sir William Herschel could hold an opinion which now seems manifestly absurd, the answer is easy and illuminating. There did not then exist a sufficient body of scientific knowledge to make any objective test of such an hypothesis possible. Sir William's only criteria as to the plausibility of any hypothesis concerning the nature of the sun were, that it must not be incompatible with the revelations of his telescope, and that it must fit in with his habits of thought; i. e., that it must be reasonable. It would be difficult to imagine a more striking illustration of the dangers which lie in too great a reliance on "reasonableness" as a factor in scientific thinking. In the absence of any concept of energy as an entity which is conserved, and lacking quantitative knowledge of the sun's radiation, there was no considerable difficulty in accepting any hypothesis whatever as to the nature of the sun, since the only possible refutation of such an hypothesis lies in the proof that it is quantitatively insufficient.

Recognition of the fact that heat is a measurable quantity presently led to attempts to measure the rate at which heat is received from the sun. The most notable of these early determinations were those of the French physicist Pouillet (Professor of Physics at the Sorbonne) in 1838. Although Pouillet gave the rather formidable name pyrheliometer to his apparatus it was nothing more than a flat metal can having one end blackened to absorb the sun's radiation and filled with water. The remaining surfaces of the can were silver plated to reduce radiation, a thermometer inserted to indicate temperature changes, and the whole mounted in such a way as to allow of convenient manipulation. Alternate observations of the rate of change of temperature in sun and shadow gave the necessary data for computing the heat received. The simplicity of the instrument

and the ease with which observations may be made suggest the possibility that it might well find a place in present day laboratory instruction as an alternative to some of the usual experiments on the measurement of quantities of heat.

Of course this or any other instrument measures the heat received at the earth's surface and the most difficult part of the determination of the quantity desired, the rate at which heat is being received from the sun, lies in the estimation of the heat absorbed by the atmosphere. In spite of the difficulty attending this correction the early determinations were surprisingly good, better in fact than many made later. Pouillet's final result of 1.76 calories per square centimeter per minute at the outer limit of the atmosphere is within ten per cent of the best modern values.

The greatest error in these determinations lay in the fact that different wave lengths of the solar radiation are unequally absorbed by the atmosphere so that it was impossible to make any single correction which accurately accounted for this loss until the distribution of energy among the various wave lengths was known. The late Professor S. P. Langley of the Smithsonian Institution overcame this difficulty by the invention of the bolometer which measures the energy in a narrow band of the solar spectrum, thus making it possible to apply the proper correction factors to the different wave lengths. The bolometer is a Wheatstone's bridge net in which two of the conductors are tiny strips of blackened platinum. One of these is exposed to the solar radiation and the rate of receipt of heat is determined by noting the galvanometer deflection. In practice a moving photographic plate records the changes in galvanometer deflections as the spectrum moves over the exposed strip. The rate at which heat is being received is proportional to the galvanometer deflections. In the hands of Dr. C. G. Abbot, present Director of the Smithsonian Institution, this instrument has made possible determinations of the value of the solar constant which leave little to be desired in the way of accuracy. When all corrections have been made Abbot finds that each square centimeter exposed at right angles to the sun's rays at the limit of the atmosphere receives heat at the average rate of 1.94 calories per minute, and that the solar radiation varies from time to time by perhaps five per cent of this amount.

Since the whole earth receives continuously an amount of heat equal to that falling upon a plane at right angles to the sun's rays

and having an area equal to that of a great circle of the earth, one may readily calculate the rate of inflow as approximately 2.33×10^{14} horsepower. This is a quantity so vast as to be meaningless except by comparison. No very accurate figures are available as to the power which all the engines and water wheels in the United States would develop if operated at full rated capacity but, excluding automobiles, it probably does not exceed 150,000,000 horse power so that the heat received by the earth in one minute would be sufficient to operate all the machinery and keep all the electric lights of the country burning continuously for more than two years.

If we ask as to the total energy radiated from the sun, instead of that received by the earth, the figures are still more staggering, for it is easily shown that the earth intercepts less than one two-billionth of the total energy radiated, so that the sun is to be rated as a heating unit with a continuous output of 5×10^{23} horse power. Even the method of comparison fails to picture the immensity of such a quantity. If one attempts to put it in terms of the power developed by machinery, as was done above, it appears that the energy which leaves the sun each second would suffice to operate all the machinery of the country for something over a million years,—and this itself probably means nothing more to most of us than "an awful lot of energy." If we consider the intensity of radiation instead of total radiation, we find that each square yard has a constant output of nearly seventy thousand horse power, enough to supply the electrical needs of a city of considerable size.

These quantitative results give quite a different aspect to the old question, What is the sun? The sun is a body which radiates at this rate and this radiation has continued without great variation for a period which must certainly be measured in millions of years. No hypothesis which does not give a satisfactory quantitative account of the possible source of this energy is tenable. In each million years the sun must either have diminished its stock of energy by 5×10^{23} horse power years or this same amount must have been supplied from outside.

Consider the hypothesis of Anaxagoras, that the sun was a ball of hot iron. The mass of the sun is about 4.4×10^{30} lbs. and if one takes the specific heat of iron as 0.11 it follows that the heat capacity is about 2.7×10^{29} B. T. U. per degree C. The 5×10^{23} horse power years radiated in one year are equal to 6.3×10^{29} B. T. U., so that the temperature must, upon this

hypothesis, be changing at the rate of some two or three degrees per year. Since the climatic conditions of the earth at the time when this hypothesis was first advanced were not essentially different from what they are today it follows that, had Anaxagoras been right, the sun must long ago have ceased to give either light or heat in quantities sufficient to maintain life on the earth.

Perhaps the rather tacit assumption of many people today is that the sun is a mass of burning gas, a ball of fire. A computation similiar to that outlined above shows that, were this true, it must have been completely burned out within the historic period.

Questions as to the nature of the sun, and especially as to its possible age, developed an unexpected scientific interest during the last half of the nineteenth century because of the growing knowledge of historical geology, the enormously long periods of the geological time scale and the relation of this time scale to the theory of evolution. This led to the formulation and testing of other hypotheses of which two are of interest. The so-called meteoric hypothesis assumed that the heat of the sun was maintained by the energy of meteors like the "shooting stars" with which every one is familiar. That some energy will be supplied to the sun in this way is unquestionable. Will it be enough? It is possible to make a somewhat reasonable estimate of the quantity of matter which these visitors add to the earth each year and it appears that, since the earth must screen about one two-billlonth of the surface of the sun, the sun should receive 2×10^9 times as much matter as does the earth. Since the limiting velocity which a body falling from an infinite distance to the sun would acquire is about 384 miles per second it is possible to compute the maximum amount of energy which could be added to the sun each year along with this incoming matter. It proves to be an insignificant fraction of the amount radiated.

In 1853 Helmholtz suggested that the energy radiated might be drawn from that of the sun's gravitational field as a result of the gradual collapse of the sun itself. As is well known the compression of any body of gas results in the production of a quantity of heat equal to the work done during the compression. In the case of a radiating gas this must set up a cycle of changes; radiation causes cooling, cooling causes contraction, contraction causes heating, heat maintains radiation. In the absence of

any other source of heat this action *must* go on, moreover it is a self-regulating process so that over any relatively long time interval the heat produced must balance that radiated, thus accounting for the constancy of the radiation during the historic period. This hypothesis fitted in well with the nebular hypothesis as to the origin of the solar system which was then widely accepted. According to this hypothesis the entire solar system had been derived from a vast nebula, a cloud of gaseous material which at some time in the remote past extended out beyond the orbit of Neptune. The age of the earth would thus be limited by the time required for the central nebula to contract from the earth's orbit to the present dimensions of the sun. As a result of the computations of Helmholtz, Lord Kelvin and others it appears that a rate of contraction such as would correspond to a decrease of 250 feet per year in the diameter of the sun would be sufficient to supply heat equal to that radiated under the present conditions. Such a contraction would not become observable with our present telescopes for about 10,000 years. Thus, so far as direct astronomical evidence is concerned, the hypothesis seemed adequate. The same computations indicated that, if the sun were originally such a nebula extending out to the orbit of Neptune, it might have been radiating at its present rate for about 25 million years. Allowance for the fact that radiation in the earlier stages was doubtless less than at present would extend the possible past life of the sun to about double this period, or 50 million years. The life of the earth must evidently be less than this latter figure, in fact the best estimates seemed to indicate a limit of not more than ten million years for the age of the earth. Even ten million years is a fairly respectable length of time, but the geologists, who after all were the people whom it was necessary to satisfy, insisted that it was only a fraction of that required for the changes recorded in the rocks of the earth; and that 50 million years, the absolute limit which could be squeezed out of the contraction theory, was no better. Each time they returned to the problem with new evidence their demands increased rather than lessened until it now appears that a period of at least 1000 million years must be allowed for the evolution of the earth. It was a very interesting situation but one very annoying to the physicist. Here was a perfectly reasonable, apparently an unescapable, source of energy which would also be quantitatively adequate were it not for the constantly increasing demands of these

pestiferous geologists to whom a million years seemed of less importance than a week-end vacation.

Thus the matter stood at the end of the last century. The contraction theory was generally accepted by those to whom it was of merely casual interest; but no one to whom it might have been of the slightest importance paid any attention to it.

At this point it seems well to follow the example set by writers of mystery stories who, having maneuvered their characters into a situation from which there seems no escape, are accustomed to intrigue one with the phrase "to be continued in our next."

ILLUSTRATIONS OF CELL STRUCTURES.

By General Botany Class, New Jersey State Teachers' College, Upper Montclair, N. J.

The following plants, easily obtainable in winter although not always mentioned in textbooks, furnish good illustrations of certain cell features.

Japanese barberry. The fruit wall shows cell sap colored by berberine, an alkaloid. This is identified by a reddish-brown color which appears after a bit is treated on a slide with potassium iodide-iodine or with nitric acid and ammonia.—Reported by J. Mahr and D. Wright.

Climbing bittersweet. The fruit coat shows orange cell sap. The aril obtains its red color from bundles of raphides (calcium oxalate crystals) in the cells. These dissolve when treated with hydrochloric acid.—Reported by H. Johnson and M. Sanford.

Red carnation. The red color is due to anthocyanin in the cell sap. The petal shows also very distinctly the middle lamella, nucleus and intercellular spaces.—Reported by H. Dunn and M. Strukel.

Coleus. The hairs on the red spots in the leaf show cell sap. The nucleus and nucleolus show well after treatment with iodine.—Reported by A. Northrup.

Cranberry. The fruit epidermis shows thick cell walls, colored cell sap and oil globules which disappear readily after treatment with chloroform. The cells, after treatment with glacial acetic acid which is allowed to evaporate, show anthocyanin crystals.—Reported by H. Bennett and P. Piaget.

Cyclamen. The sepal contains oil globules which turn yellow after treatment with Sudan III.—Reported by I. Kunzmann.

Nasturtium. (Tropaeolum). A section of the embryo shows plainly the middle lamellae and amyloid thickenings of the cell walls. Methylene blue in water, very dilute, stains the walls well.—Reported by F. Cross.

Poinsettia. The red color of the floral bracts (leaves) is caused by cell sap.—Reported by I. Kunzmann.

Tulip. The yellow perianth parts exhibit chromoplasts, middle lamellae, large nuclei and stomata.—Reported by H. Kolter and H. Sanford.

INDIVIDUAL AND CLASS PROJECTS IN BIOLOGY.[1]

By J. L. Cooprider,

Central High School, Evansville, Ind.

There is a time in the experience of every real teacher when he should take time out to review some of the many principles of teaching, which he learned in college in order to pass the examinations given by the professor. Many are lucky enough *to pass* those tests and are promoted to the ranks of teachers. It so happens that many attempt to forget their college experiences, and it often happens that many succeed very well. I do not wish to recall those past experiences, but I do think that such a worthy method of teaching as the project needs to be gone over again from time to time. I wish to summarize some of the weak points of the project[2], also, to give some of my experiences with class and individual projects, with the hope that I may give some suggestion that will again kindle the project idea in each real biology teacher.

By definition, the project is an appealing, purposeful, concrete problem, the solution of which is planned and executed by pupils. The project is not a panacea for all of our educational imperfections. Like every other good servant it may easily be worked to death. The project is not a new educational *fad*, but of late years it has been found that the project method is a tool for intensive drill in proper methods of thinking. It is a laboriously slow method of acquiring knowledge, of imparting skills, and of developing appreciation of the common-place objects and phenomena of nature. It is the business of education to give to the pupil a mastery over the most important knowledge, that finest appreciation, and those essential skills that the race has acquired largely through the project method. But the student must make acquisitions in years where the race has taken ages. Education cannot take the time to repeat all the projects that the race has stumbled through. It may, through the project method, help the pupil acquire some mastery of the fine art of accurate thinking.

Projects are not intended to bring about a re-organization of

[1]Read before the Biology Section of the Indiana Teachers' Association, Indianapolis, Oct. 18, 1928.

[2]Herring, John P., "Criteria of the Project," *Teachers College Record*, XXII, pp. 329 333. 1921.

Hosic, James F., "Criteria of Success in Project Teaching," *Journal of Educational Method*, II, pp. 329-335. 1923.

Horn, Ernest, "Criteria for Judging the Project Method," *Educational Review*, LVIII, pp. 93-101. February, 1922.

Kilpatrick, W. H., and Others, "Dangers and Difficulties of the Project Method and How to Overcome Them," *Teachers College Record*, XXII, pp. 283-321. September, 1921.

the curriculum. Customs and practices are "inherited" by the teacher in the form of a so-called *course of study*. The project method calls for additions, eliminations, and revision of the subject matter within the subject. It is not to be thought of as an isolated method of classroom procedure. On the contrary it requires a deeper knowledge of the psychology and principles of school activities. It demands a broader knowledge of subject matter in its relation and application to concrete life activities.

Projects are not informal, unconventional classroom activities. Every project has an educational basis or it is not a project. The method is not a substitute for poor teaching nor an excuse for idleness on the part of the teacher. Using the word *project* for want of a better term does not make it one. One marked drawback to the project method is that there is often a lack of sincerity on the part of both the teacher and the students. The method is dangerous in the hands of the shirker since it furnishes too much leeway for this type. The method is somewhat complicated. It is different from the familiar traditional methods. Teachers continue to do the "thinking, draw up plans, and prescribe procedures for the students." With these things done for the student there is no project and there is nothing to be mastered except the subject matter involved.

Projects are not activities that must be initiated by the pupils. Such activities are worthy but it is the business of the teacher to direct pupil activity rather than merely discover it. The real project teacher will always be suggesting projects and he will suggest them with such tact that the students will adopt them as their own. That teacher will always recognize offerings of pupils and determine which are best and which should be used.

The success of the project is limited to the scholarship of the teacher. The method requires greater skill and initiative. It is no easy task to utilize the spontaneously expressed or easily stimulated interests of students. It is difficult to follow up pupil interest so that it may be utilized in such a way that it will yield the greatest possible values. The teacher must have a clear conception of the project method together with its complications and limitations in order to direct such activities so skillfully as to include the appropriate subject matter of the desired course as well as the development of scientific thinking.

The project may be done either by the individual or by the class. In the individual project, a student selects a problem

which he wishes to solve for himself. In the class project, the group purposes to solve a common felt difficulty. In the class project each member seeks to contribute to the knowledge of the other members of the group. All individual projects should contribute to the class as a whole, but these need not be related. A class project may include individual projects. Individual projects are completed as small units, while in the class project, each unit of the individual student contributes to the large unit upon which the class is working.

Permit me to illustrate an individual project. I once had a class discussion of the grasshopper at the beginning of the year. During the course of the discussion it was stated that the body of a grasshopper had many parts that were analogous to our body. One girl, showing her want of knowledge and at the same time a desire for the same, took exception to what was said, stating that she did not see how it could be possible. I suggested that she take a grasshopper apart. She thought that it would be a very good thing to do and asked if she could do so. (Note: We have here the first step of a project, namely, purposing or desiring to do a thing, in this case initiated by a suggestion.) The girl proceeded to get a large grasshopper. (Note: The second step, planning a concrete problem). Upon looking about the country for a victim she collected a large number of insects, but, upon looking them over, and, after taking two or three apart, she decided that she needed some help. (Note: The third step, the execution of the problem.) I seemed to be the only logical person to whom she could go for help, so she asked me where she could read about the parts of a grasshopper. After some reading, a little study, and further observations (Note: the fourth step, the generalization), she decided and reported to me that grasshoppers had parts similar to the parts of our body. (Note: The fifth step, the evaluation of the findings.) Please note again that all of the steps of the thinking process were performed by this girl, purposing, planning, execution, generalization, and evaluation. The last step is the most important. Without it the problem is not a project. In this, the teacher is a most important factor. This outcome is the germ that furnishes the drive or inner urge for further projects or a continuation of the problems that naturally arise. Both the process and the outcome are satisfactory to the pupil as well as the teacher. As a teacher, I felt that I had completed a successful project, although it was different from that of the girl. As a student, the girl had the same feeling.

Another illustration of the individual project may be in order. During the same discussion of the grasshopper mentioned above, a young country boy very much doubted a statement that grasshoppers laid eggs and also that the young grasshoppers are wingless. He said that he had lived in the country all his life and had not seen either of the things mentioned. (Note: A typical situation.) Unknown to me, this young gentleman decided "to show me and the class up," since we were city people and did not know any better. This lad proceeded to call in the countryside, and, together with his pals, the matter was settled. On the next Monday morning, following the preceding Sunday afternoon, this "ignorant" biology teacher and the "less informed" class were presented with a complete life history of the grasshopper. You will note that strong opposition to the truthfulness of knowledge in this case led to the stimulation of a purposeful Sunday afternoon activity, providing for one student at least, a concrete situation, and resulting in the completion of the steps of the thinking process, hence a successful project.

Permit me to illustrate a class project! Some time ago I was developing one of the units of my course on "our community in relation to health." As an assignment I asked the class to make a list of the things in the city that they considered detrimental to health. The students did as directed. (Note: An assigned problem, not a project; a subjective lesson, solved by pencil and paper thinking.) This may have been purposeful and worthwhile, but it was not a project until a concrete situation was introduced. Note the development of this concrete problem, by following the trend of the discussion.

One boy said during the lesson, that he did not think that our city would permit the existence of some of the things the class had named mentioning particularly the open privy vaults and the sale of non-government inspected meats. Another student asked whose business it was to prevent such conditions if they did exist. Another suggested that it was the business of the health inspector. Then came, "Who is the health inspector?" then, "Do we have a food inspector?" also, "Do we have a meat inspector?" Some stated that they had seen signs stating that "This store has been inspected——" but that they had noted nothing that would indicate that meats had been inspected. Another stated that he had seen meats with government stamps. Another joined in that he had seen meats without stamps. Now, one fellow suggested, for the group, an inspection trip through

our largest packing house, if such could be arranged. Typically, all joined in the suggestion and we have the first step of a class project. I was the one to whom they turned for assistance in arranging the trip. Arrangements were made and the trip was completed.

This class found government inspectors at work. You should have heard the line of questions when the opportunity presented itself. The boys learned that this was the only packing house of four supplying meats to the city that had government inspection; that when this plant found a cow with T. B. the internal organs were made into tankage but that the meat was often sold in the city markets for two reasons, first, the federal laws prohibited out-of-state shipments of these products and second, the city had no laws upon which the health, food, or meat inspectors could act; and they learned that meat with trichina or tapeworm, or any other disease could be sold also.

Upon returning to the classroom, I found the ire of the class was growing fairly well. Here was a situation and "something ought to be done about it." Here was my opportunity to make a project out of a trip. This gave opportunity for several individual projects as well as several activities by the class as a whole.

One student made a second trip to the packing plant and discovered a cow with tapeworm larvae. He brought the heart to class with him and a study of the tapeworm followed. He unearthed somewhere a real tapeworm, so the class had a life history. This study brought up the open privy problem again. A survey was made by the class of the number and condition of the toilets for several blocks around the school building. Flies were observed in great numbers. A study of the fly followed. One student made some models showing the stages in the life history of the fly. Another student made the problem more concrete by actually growing some flies from eggs and presented all stages to the group. Another student found some enlarged pictures of fly legs, feet, and tongue, showing how the fly carried filth. Some rats were observed on the survey trip, so the rat came in for its share of punishment in the study. Some rats were killed and brought to the laboratory. One rat was found with a tapeworm, another had a swelling like a goitre, another had ulcers in its stomach, and another had wounds which had not healed thus permitting flies to lay eggs and maggots were found working in the flesh. I shall not attempt to tell all that happened in this class project. The study of the filthy rats, the

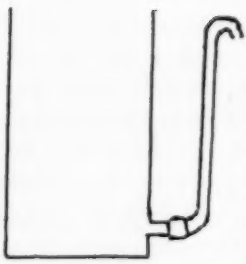
study of the tapeworm, the sight of the open privy with its flies, the T. B. cows, and so on, proved to be of real value. The boys talked among their friends. The reporters of the school paper wanted articles. Soon the city newspapers wanted stories. Mark you, this is a part of the project, there was a teacher of biology on the throne!

What happened? The city Kiwanis Club staged a contest and offered prizes for the killing of rats. Their campaign was partially successful. Two ordinances were introduced in the city council—one to abolish the open privy and the other to enforce the selling of government inspected meats in all shops of the city. The first ordinance passed and became effective. The meat ordinance failed to become law because of political opposition.

I trust that you have caught the spirit of the project!

IMPROVED OVERFLOW CAN.

By Clarence B. Hill,
High School of Commerce, Boston.



The ordinary overflow cans used in secondary schools in connection with experiments on finding volume of irregular solids, or finding amount of water displaced by floating bodies, have serious disadvantages. Waves formed on the surface push out more than the correct quantity of water, there is no exact level where the water ceases to flow, and any floating body is very likely to become stranded across the outlet and so impede the discharge of the water. A remedy is to change the outlet from the top to the bottom of the can as follows:

Hold the edge of the bottom of the can over a flame, rotating the can slowly, until the solder melts and the bottom of the can may be pushed off by pressure from the inside. Transfer the bottom thus freed to the top of the can and solder it there. Invert the can. The outlet tube is now at the bottom.

Bend a piece of glass tubing of about the same external diameter as the outlet tube into the shape shown in the diagram. Join it to the outlet tube by a bit of rubber tubing. When the can is filled the level of the water inside the can will be at the height of the end of the glass tubing.

Any object placed in the can will now force water out at the bottom, consequently no surface waves will affect the quantity. The adhesion of water for glass is great enough to keep the glass tubing filled very exactly. There is no possibility of the outlet being clogged by a floating body. The error for successive trials of the same object should be not more than the equivalent of one drop of water. Careful trials show a deviation of not more than one-tenth of a gram.

SOME FIRST-HAND INFORMATION CONCERNING SCIENCE CLUBS.

By HANOR A. WEBB,

George Peabody College for Teachers, Nashville, Tenn., Editor, "Current Science."

"Not forsaking the assembling of ourselves together, as the manner of some is."—Hebrews 10:25.

When, a few months ago, we asked several hundred science teachers about their science clubs, only four replied that they did not want one. Certainly, there is no strong *antagonism* on the part of teachers toward these organizations. Sixty-one teachers reported "no club," but they would like to have one if conditions became propitious. Surely there is *interest* in the matter. One hundred fifty-three gave information as to their club; there is indeed some genuine *achievement* in this field. One additional conclusion may be reached in respect to the fair number who kept our reply card as a souvenir; there is undoubtedly much real *indifference* to the science club idea, due, no doubt, to whatever particular germ it is that paralyses initiative and develops laziness in members of the teaching profession.

The replies received have given some first-hand information concerning science clubs, not as they should be, perhaps, but as they are. Some of this information concerns the simple mechchanics of their meetings; the rest reveals the tendency of their interests and, presumably, the general nature of their programs.

THE ENROLLMENT IN SCIENCE CLUBS.

The club activities of 5,608 members are presented upon our cards of information. This, for the 146 clubs that reported their numbers, is an average of 38.4 students in each club. A few very large organizations have unduly raised this average; the half-way (median) student is in a club of 45 members. The half-way (median) club has but 29 on roll—a more truly characteristic number. The quartiles are 20 and 45 members respectively—there is a concentration of clubs near the thirty mark as to enrollment. Indeed, as one teacher noted upon his card, "This seems to be about the right number for a good program."

CLUBS LARGE AND SMALL.

One of the first assumptions concerning science clubs might be that large ones and small ones would operate on different

plans. The smallest club reported seven members, the largest, two hundred forty members. To discover any effects due to such inequalities in size, the data concerning clubs of 40 or more was separated from that of 39 or less. The median (29) might have been chosen as the dividing line, but it did not seem fair to designate a membership of 30 as "large." Above 40 students, any science teacher will admit that his group is crowded.

There are forty-one "large clubs" and ninety-four "small clubs" giving information both as to numbers and time of meeting.

How Often Do Science Clubs Meet?

How frequently shall a club meet? Not too often, lest the club appetite be satiated, or unreasonable time be taken from those "sacred fundamentals" that some teachers vehemently defend against the modernistic science club idea. Not too seldom, lest interest lag.

A table shows the existing practice of the science clubs reporting:

Frequency of Meeting	Large Clubs		Small Clubs		All Clubs	
	No.	%	No.	%	No.	%
Oftener	1	2.4	2	2.1	3	2.2
Each week	12	29.3	39	41.5	51	37.8
Every second week	15	36.6	46	48.9	61	45.2
Every third week	0	0.0	1	1.1	1	0.8
Every fourth week	12	29.3	4	4.3	16	11.8
Less frequently	1	2.4	2	2.1	3	2.2
Totals	41	100.0	94	100.0	135	100.0

Science clubs meet weekly, bi-weekly, and monthly—these frequencies seem well crystallized. Large clubs seem almost equally divided in their use of these three periods; small clubs distinctly prefer the more frequent assemblies. Nearly half of all clubs—large and small—meet each alternate week. May we quote again—"This seems just about the right time between meetings."

Do Science Clubs Meet During School Hours?

The even division into "in school" and "after school" meetings was surprising. Science clubs—large, small, or all together—report their practice as indicating an almost 50-50 preference. A table makes this clear:

Time of Meeting	Large Clubs		Small Clubs		All Clubs	
	No.	%	No.	%	No.	%
After school	22	53.7	46	48.9	68	50.4
During class periods	19	46.3	48	51.1	67	49.6

Any set of figures in agreement, however, may conceal conditions of contrast. A table shows the influence of frequency of meeting upon the time of meeting:

Frequency of Meeting	Time of Meeting: After School		In Class Period	
	No.	%	No.	%
Oftener	1	1.4	2	3.0
Each week	14	20.6	37	55.2
Every second week	40	58.9	21	31.3
Every third week	1	1.5	0	0.0
Every fourth week	11	16.2	5	7.5
Less frequently	1	1.4	2	3.0

In general, science clubs conducted after school hours adopt the (first) bi-weekly and (second) monthly sessions. Those utilizing the class periods find it convenient to meet oftener, and schedule (first) weekly and (second) bi-weekly programs.

What Are the Interests of Science Clubs?

A table shows the interests of science clubs, as reported by their sponsors. Most of these interests are multiple; only occasionally does a teacher record a single subject which—presumably—might be the sole theme of its programs.

Large Clubs.

Occurrence.

Chemistry....17
General Science....14
Physics....11
Biology....9

Miscellaneous: radio, 5; nature, 4; experiments, 2; geography, 2; photography, 2; agriculture, 1; botany, 1; collections, 1; health, 1.

Small Clubs.

Occurrence.

General science....30
Chemistry....26
Physics....23
Biology....18

Miscellaneous: nature, 6; radio, 6; astronomy, 4; photography, 4; experiments, 3; aviation, 3; birds, 2; botany, 2; current science, 2; meteorology, 2; engineering, 1; field trips, 1; geology, 1; physiology, 1; zoölogy, 1.

All Clubs.

Occurrence.

General science	44
Chemistry	43
Physics	34
Biology	27
Radio	11
Nature	10

Miscellaneous: See other columns.

The four predominant high school sciences—general science, chemistry, physics, biology, in the order named—are the foundations for science club programs. This is an expected and—to some—a comforting fact. Science clubs are not bizarre chasings after scientific fads and fancies. They are substantial teaching devices; they are training grounds for the next generation of scientific meetings, as, for example, the Annual Meeting of the Central Association of Science and Mathematics Teachers, Thanksgiving week, November, 1950. Even if we do not care to look so far into the future for a harvest, we may feel sure that the science club of the present pays good dividends of interest for the investment of effort.

COEFFICIENT OF FRICTION OF A LIQUID.

By Harvey A. Zinzer,
Hanover College.

Measurement of the Coefficient of Friction of a Liquid by its Rate of Flow through a Capillary Tube: A tube about 30 cm long and with an approximate uniform bore of about one millimeter must be selected. A piece of rubber tubing of the proper size and length to connect a large funnel to the above tube, a stand to support the funnel, a thermometer, a pinch-cock, a breaker and a graduate or balance to measure or weigh the quantity of liquid passing through the tube in a given time, must be provided. Determining the mean pressure of the liquid during a run, the volume of liquid passing through the tube and the length and bore of the tube, we know the viscosity of the given liquid by the relation

$$\eta = \frac{\pi\ p\ r^4\ t}{8\ l\ V}$$

where V is the quantity of liquid passing through the tube in time, t; p is the mean pressure of the liquid; l is the length of the tube, and r is the mean radius of the bore. This is also a rather familiar experiment, reference to which can be found in Kohlrausch's "Physical Measurements," translated by Waller and Procter and published by Churchill, London; also Watson's "Practical Physics," mentioned above.

COMPARISON OF CHEMISTRY TEXT BOOKS.

By Wilhelm Segerblom,

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In the course on the Teaching of Chemistry given in the Institute of Chemistry of the American Chemical Society at State College, Pennsylvania, during the summer of 1927 the discussion turned to the good and bad points of existing chemistry texts used in high schools. In an attempt to formulate the aspects of a chemistry text which should make it a successful text from the point of view of giving the student a sane working knowledge of the essentials of elementary chemistry presented in a clear and teachable way, and in addition to learn how some of the more recent texts meet these criteria, the members of the course were asked to examine some recent texts closely and formulate full answers to a set of twenty-two questions framed so as to bring out data on the aspects mentioned above.

From the large number of texts which were then in considerable use four were finally selected which either were very recently published or were new and considerably revised editions of texts already established; furthermore, texts with radically different methods of presentation of material were selected to get a line on this aspect, because of late there has been evidence of a dissatisfaction with the stereotyped form of text and a desire to try out new methods of presentation.

The four texts selected are indicated throughout this paper by the terms Text I, Text II, Text III, and Text IV. The courtesy of the publishers in making special arrangements so that the members of the course could have individual copies to examine is hereby gratefully acknowledged. The credit members of the course, from whose investigations the following statements have been compiled, varied from teachers of long and wide experience to graduating students who were planning to make the teaching of chemistry in high and secondary school their profession. The location of these members extended from new Jersey to California. To these members* the writer wishes to make grateful acknowledgment for the investigations which have made this paper possible.

It is to be regretted that other excellent texts now in use could not be included in the above list, but time did not allow of such

*L. D. Amstutz, F. W. Arnold, E. R. Hansen, J. A. Hibschman, C. P. Hudson, H. W. Huston, J. P. Jewell, J. M. Maclay, J. Rider, S. Z. Sporcic, L. N. Stackhouse, M. C. Welker.

an extended comparison. Furthermore, the primary purpose of the study was, not to determine which text book in the market might be the best one, but rather to discover the method of presentation which met with approval and to emphasize those aspects of the text which gave this tool its value. It was purely accidental, and not at all intentional, that the texts finally selected were all written by teachers who are studying the problem from first hand experience.

In the following paragraphs will be found the questions raised and aspects to be studied, followed in each case by opinions tabulated from the theses passed in by the members.

1. State three or more outstanding reasons given in the preface telling why the book was written.

Text I: (1) To present the electron theory up-to-date and show its applications, (2) to avoid too many technical terms, (3) to promote individual thinking by well chosen and revised "power questions," and (4) to stress the social service of chemistry.

Text II: (1) To teach the fundamentals of chemistry as a preparation for both college entrance and for life, (2) to introduce facts first and then proceed through explanations to generalizations based thereon, (3) to present organic chemistry immediately after carbon and fuels, and (4) to keep in mind the point of view of both teacher and pupil.

Text III: (1) To present a new type of text made necessary by the recent rapid development of chemistry, (2) to prepare students, not only for college, but primarily for commerce and other walks of life, (3) to emphasize the application of theories and laws rather than to develop them, and (4) to start the course by beginning with familiar substances in order not to discourage the pupil with too much new material.

Text IV: (1) To interest the pupil by presenting familiar material in an understandable manner, (2) to teach the basic principles of chemistry, (3) to arrange the material in a psychological, rather than a logical, manner, and (4) to present material suited to the needs of both boys and girls.

2. Does an examination of the book indicate that these objects are attained? Give one or two examples to back up your answer.

Text I: Most members conclude that on the whole it attains the desired objects. The language seems easily understood, and the material stimulates individual thinking. Not all agree that theory is given in small doses.

Text II: Most members conclude that it attains the desired objects. Presentation of fundamentals, and the chapters on hydrogen, chlorine, and iron received favorable comment. Placing organic chemistry immediately after the oxides of carbon meets with approval. One mentions in particular the attractive mechanical make-up of the book, the easily understood English, and the interesting illustrations, as some of the many aspects in which the author has kept in mind the viewpoint of both teacher and pupil.

Text III: Most members conclude that it attains the desired objects. Many topics are mentioned to show how the applications of chemistry are stressed. One member says: "The authors start with the metals familiar to the average pupil, next follow the oxides of these metals and the mining of ores. Then follow the non-metals and in their order the more difficult subjects are introduced. This, I believe, would be a more logical order and certainly less confusing to the pupil starting with the study of chemistry."

Text IV: Most members conclude that it attains the desired objects. Students are constantly made aware of what is around them. Correlation of text and experimental work is close. Interest is aroused by frequent use of questions—those at the beginning of the chapters designed to show that chemistry is not a thing apart from the pupil's life, putting paragraph headings in question form to arouse curiosity, and summary questions to help the pupil organize his materials.

3. Number of pages of text and number of references in the index.

	TEXT I	TEXT II	TEXT III	TEXT IV
Number of pages of actual text..	587	545	423	776
Preface and contents	9	8	9	17
Appendix	8	7	23	42
Index	20	16	10	26
Total number of pages	624	576	465	861
Number of references (estimated)	2,000	1,400	1,200	3,600
Average number of references per page of text	3.4	2.5	2.8	4.6

4. Is the index satisfactory? Test by looking up (a) equations, (b) kinds of chemical change, (c) valence, (d) some one theoretical topic, (e) some one metal.

The members seemed to think that on the whole the indexes had been carefully prepared. Text IV received very favorable comment by several. The indexes in the other three texts could

be considerably improved, judging by the specific criticisms.

One member made the following tabulation on the number of references in each text on each of the five topics listed above:

	TEXT I	TEXT II	TEXT III	TEXT IV
Equations	8 (good)	3 (incomplete)	3 (incomplete)	16 (very complete)
Chemical change	2 (incomplete)	1 (incomplete)	2 (incomplete)	8 (complete)
Valence	8 (satisfactory)	5 (incomplete)	5 (incomplete)	19 (complete)
Theoretical topic (atomic theory)	2 (incomplete)	7 (satisfactory)	2 (poor)	5 (complete)
A metal (iron)	23 (satisfactory)	16 (satisfactory)	6 (incomplete)	52 (most complete)

One member commented favorably on the placing of page numbers in a straight, vertical column as in Text I, and on printing the most important page references in bold type, as in Text IV. Another finds in Text III under "Chemical change" a reference to the definition on page 434 (misprinted page 432 in the index) and under "Change, chemical" a reference to the definition and explanation on page 20.

5. Test to see if the references in the index are matched by material on the page indicated.

Some members compared the topics they listed in answer to question 4 with their mention in the index, some compared topics "hit or miss," while one looked up about twenty-five topics in the index and compared with the material on the pages indicated. Practically no discrepancies were discovered.

6. Also test by seeing if there are any important mentions of the topic in question in the body of the text but omitted from the index.

Several members stated substantially that topics discussed in the body of the text seemed to be well covered in the indexes of the respective texts. A few members, however, found some topics in the body of the text which did not seem to have references therefor given the index. Fifty omitted topics were mentioned, varying from eight to eighteen per text. Some of these topics, curiously enough, were important topics.

7. How many illustrations in each text?

Text I has 240 illustrations and 21 portraits. Text II has 207 illustrations including portraits. Text III has 197 illustrations and 3 portraits. Text IV has 160 illustrations and no portraits.

8. In a general way which text seems to you to have the most satisfactory illustrations in respect to clearness, ability to tell their story, and relevancy to the text matter?

Text II is given first place by 7 members and Text III is given first place by 5 members.

Two members who give first place to Text III speak of the way the illustrations catch the eye and the descriptive captions tell the story. Comments on Text II include:—diagrams are much clearer than the photographs; some of the diagrams might be transferred to the laboratory manual; the set-in portraits of chemists are not effective; the lettering and arrows on the diagrams make them very clear. One member states that the photographs of industrial processes are not large enough or clear enough in any of the texts.

9. List the texts in their decreasing order of merit as regards illustrations.

The four texts arranged in decreasing order are: Text II, Text III, Text I, and Text IV. Descriptive captions are generally preferred to mere titles under illustrations.

10. Compare the diagrams in the different texts showing the laboratory preparation of hydrogen and list them in their decreasing order of value as regards clearness, ability to tell their story, and agreement with efficient laboratory practice. Mention briefly the good or bad points which determine your listing.

The following quotations serve to show the trend of the comments:

Text II: "The diagram is clear cut and well defined. It is correctly assembled and well labelled. Being a cross section diagram, it might be improved by making continuous lines for the thistle tube and the delivery tube through the stopper of the bottle and by making the horizontal lines of the stopper go just to the thistle tube and delivery tube and not through them."

Text I: "The diagram is a cross section diagram, but not labelled. It could be improved by continuing the lines of the thistle tube and delivery tube through the stopper." "Use of rubber hose is inadvisable. Bottle catching the hydrogen seems to be sitting precariously." "It is pretty evident that such a trough will overflow from a single bottle of water."

Text IV: "A cross section diagram would be much more clear cut. This photograph is very indistinct. It gives no idea of the positions of the delivery tube and the thistle tube in the flask, nor the position of the delivery tube in the bottle. It also gives the impression that the flask is filled with solid material. However, it includes the use of a glass plate, which the other diagrams do not show."

Text III: "This book is placed last because it has no diagram of the hydrogen apparatus."

11. Do the same for the laboratory preparation of sulphur dioxide as you did for hydrogen in the preceding question.

Comments on Texts II and I are similar to those on these two texts under the preceding question. One member points out that in Text II there is too much sulphuric acid in the flask, while another points out that the directions call for gentle heating of the flask and the diagram shows a large flame under the flask.

12. Compare the illustrations relating to the extraction of iron from its ores and to the manufacture of steel in the different texts. List the texts in their decreasing order of value as regards the iron and steel illustrations. Mention briefly the good and bad points which determine your listing.

The result is very close to that given under question 9 but in this case (iron) opinion seems to vary considerably. Good points include: well labelled diagrams, proper relation of one part of the plant to another, showing methods of tapping, the lettering of photographs to show the different parts, full explanation of pictures, showing the inside of the "stove," and interest aroused by half-tones. Poor points include: poor labelling or no labelling of parts of the diagram, use of photographs instead of cross section diagrams where operation is to be shown, some diagrams too small, too few illustrations, indistinct photographs, and too brief explanation of pictures.

13. Is the clearness and teaching value of the text matter on iron and steel in the different texts in substantially the same order as the value of the illustrations? If not, indicate why you should list them in a different order as regards text matter.

Half the members list the texts in the same order here as in the preceding question. The rest of the members make slight changes in the order but these changes largely cancel each other.

14. Approximately how many pages are devoted to summaries of the chapters in each text?

Text I about 36 pages, Text II about 30 pages, Text III no summaries at all, and Text IV about 77 pages.

15. Which text has the best summaries? Which the next best?

The summaries in Text IV are more complete and they are in outline form, which helps the student to organize his material. Several, however, like the summaries in Text I because of brevity and use of bold face type. One member points out that Text II

summaries cover the material in the text more fully. Another thinks that a very long summary is worse than none at all.

16. Approximately how many pages are devoted to exercises or review questions in each text?

Text I about 57 pages, Text II has about 32 pages, Text III about 32 pages, and Text IV about 30 pages.

17. *List the texts in decreasing order of value as regards the exercises or reviewing questions.*

The texts are very nearly of equal value in this respect.

18. *List the texts in decreasing order of value as regards the clearness and teaching value of the section on the writing of equations.*

Here again the texts are of nearly equal value. Comments include: students find it easy to balance the equations by the method in Text III; Text IV gives full explanation of the various kinds of equations and their meaning; Text II formulates a set of rules which the student may follow easily, and Text III uses a similar method; Text I leaves too much to the student's imagination.

19. *List the texts in decreasing order of value as regards the occurrence, preparation, properties and uses of chlorine.*

Text II is placed first by a wide margin, with Text I a fairly close second; Texts III and IV take poor third and fourth place.

20. *Give briefly your reaction towards the treatment of the electronic structure of matter in each text.*

Because of the nature of this topic, opinion was naturally much divided and it is hard to ascribe any satisfactory rating. Let it suffice to quote some of the comments.

Text I: Too detailed a discussion for a high school course; excellent explanations and cuts; conception of the nucleus not clear enough; danger that the wording may lead the student to consider the theory a fact; a couple of paragraphs might be omitted; necessary for the teachers to emphasize that it is a theory, not a fact; authors take the electronic theory too seriously; theory too theoretical for the majority of students.

Text II: Discussion a bit too brief; lack of diagrams; description is clear; gives only enough material to satisfy the student that electrons, protons, atoms, and molecules actually exist; the author is very sane in his treatment and gives only what he thinks is essential; important material not stressed; the relation between mercury and gold might be replaced by a better example; gives the cream of the electronic theory.

Text III: Sufficient discussion for high school work; diagrams help to visualize the theory; the theory connected with the Periodic Table; does not give a very clear conception of the nucleus; part of the text does not mean much unless the student has had physics; doubt whether the explanation is simple enough for secondary school pupils to grasp.

Text IV: Brief clear explanation; lack of diagrams; should be in the body of the text instead of in the appendix; danger that this presentation may lead to erroneous conceptions; appendix is a good place for the electronic theory.

21. *What chapter in each text do you like the best and why?*

The answers to this question do not lend themselves particularly well for comparative study. The topics in the favorite chapters are listed below, the figure in parentheses indicating the number of times the topic in question was mentioned.

Text I: Electronic structure of matter (3), gaseous and liquid fuels, solutions, sodium and potassium compounds, iron, hydrochloric acid, carbon compounds, and calcium compounds.

Text II: Fuels and flames (3), organic (2), atomic theory (2), silicon and boron, calcium and its compounds, nitrogen oxides and acids (3), suphur oxides and acids, and chlorine.

Text III: Principles of separation (4), colloids, organic, iron (2), foods, equation writing, history of chemistry, obtaining of salts, and chapters one to five.

Text IV: Proteins (2), coal and carbon (2), wholesome water, equation writing, fire building and burning, ions and solutions (2), organic, and nitrogen compounds.

It is impossible to match the reasons against the individual chapters mentioned above. The choice seemed to be governed by the liking of the member for a particular topic, by the clearness and excellency of presentation, logical development of the topic, value in educating the public, uniqueness, happy combination of text and illustrations, popular appeal, practical aspects of the topic, ease and simplicity in presenting a difficult topic, ability to make the pupil think, and break away from the traditional oxygen-hydrogen-water-gas law type of beginning for elementary text.

22. *Look over the table of contents in each text and tell briefly your opinion of the order of topics the authors have selected.*

The following statements are a fair expression of the opinions of the members.

Text I: The authors follow the old stereotyped order of topics, well arranged according to the orthodox college arrangement, still preferred by conservative members; two members speak of this method as plunging the student into the depths of chemistry before he is really ready to be plunged; another thinks there is too much theory in successive chapters.

Text II: This follows the old accepted order of topics, but the book is more an academic presentation of the subject; one member speaks of the pleasing method of presentation and the systematic way each chapter leads up to the following one.

Text III: The authors have begun with familiar and tangible material; students are more interested in this type of presentation, which shows good pedagogy; several members comment favorably on this method of approach; one considers it of doubtful value though the purpose is understood; another questions why oxygen is put before water, and why photography comes before metallurgy.

Text IV: The authors follow a somewhat modified form of the old order of topics; their treatment is not so academic but more on the order of a popular presentation; one member objects to presenting neutralization before work on ions and ionization; the omission of the halogens from the table of contents seems serious; another does not like to see solutions taken up so near the beginning; still another thinks that chapters three and four on water might come more appropriately after chapter six on hydrogen.

Conclusion: If the few opinions expressed by a few teachers on a few textbooks on elementary chemistry as recorded above serve to lead to a closer examination of the other texts on the markets or to an examination of texts on the part of other teachers, then one object of this tabulation has been attained.

In this connection it is very appropriate to refer the readers to The Science Classroom, Vol. VI, No. 5, published by the Popular Science Publishing Co., 250 Fourth Avenue, New York City. This issue contains a full page article on the qualifications and use of science texts.

In preparing this material for publication about one half of the data had to be omitted but the author will be glad to supply any specific items from the omitted parts to any who need them.

JUNIOR HIGH SCHOOL MATHEMATICS.

By Walter W. Hart,
University of Wisconsin.

A proper consideration of junior high school mathematics calls for a perspective view of the junior high school movement. All that is possible in a brief article is to recall that this movement started years ago in agitation for a six year high secondary school; that the movement, in its narrow but popular sense, proposes a new organization of grades seven to nine, inclusive, (in Northern States), (a), preferably as a separate school, or (b), possibly, as the lower half of a six year high school,—in both cases, however, housed and administered separately from the lower grades; that, in a larger sense, the movement embraces all means of improving instruction for children in grades seven to nine inclusive, independent of, although including such particular means as new housing and administration.

The narrow interpretation of the movement serves as a brake on its progress, because it retards and even prevents affording the advantages of the movement in many communities, owing to the difficulty or impossibility of providing the new buildings and administrative machinery which are demanded in the narrowly conceived junior high school. This is unfortunate because these obstacles are, in fact, only the externals of a junior high school.

The broader interpretation of the movement is at once a blessing and a curse. By the leverage of the popularity of the movement, schools are able to make improvements in the curriculum and the instruction which would not be possible otherwise, in many cases, because of the inertia of educational tradition. On the other hand, and this is the "curse," this very opportunity is grasped most avidly by the opportunist, the faddist, the extremist, with the result that every strange idea of education has been offered as specially necessary and applicable in the junior high school. Nevertheless, it is this broader conception of the junior high school movement which should be dominant, because most of the valid aims of the movement are quite compatible with the present organization, administration and housing of grades seven to nine inclusive.

These aims, to summarize, are:

a. To overcome some of the problems of retardation and elimination in these grades;

b. To provide for the more adequate education of youth—whatever that may be;

c. To provide for more rapid education, and more flexible education for children in these grades.

The means proposed include:

a. Modifications of organization and administration,—of which departmental instruction under specially trained teachers, and promotions by subjects are most important, and these are possible in most schools;

b. Changes in curriculum, including elimination of obsolete and too difficult material, emphasis upon material which has social or economic significance, and gradual introduction to secondary school subject matter,—all of which are possible in most schools;

c. Modifications of methods of instruction and modes of class management,—most important of all, and entirely possible in any school having adequately trained teachers.

These proposals in their general form are not at all new. In particular forms they have been practiced in many schools for years. One of the principal functions of the junior high school movement is to universalize them. The application and the implications of these means in the subject mathematics will now be considered.

First of all, the aim of junior high school mathematics is to provide the best possible course in mathematics for grades seven to nine inclusive, *considered as an educational unit.* The new idea here is embodied in the phrase italicized. Instead of having three separate courses in mathematics in these grades, there should be one course functioning in the three grades. This is one definite means of "bridging the gap"; more important, this is the means of making a better course in mathematics.

In terms of subject matter, the aims of this course should be:

a. To review in each grade the essentials taught in preceding grades, doing so indirectly, when possible, but directly, if necessary; in particular, to review in grade nine (first year of "high school") the arithmetic taught previously, because arithmetic is the practical mathematics for most people. This aim calls for unusual perseverance and systematic instruction on the part of the teachers, and, in the case of ninth grade teachers, it may call for some persuasion "from above";

b. To teach in each grade the maximum of modern arithmetic for which the pupils are prepared,—including, in grade nine,

any arithmetic which has been too difficult previously;

c. To teach some intuitive geometry, as defined and for the special purposes enumerated below,—beginning in the seventh grade;

d. To teach some literal arithmetic and the beginnings of algebra before grade nine, for reasons given below;

e. To complete by the end of grade nine a strong course in modern algebra.

In terms of mental habits and attitudes, the improvements sought are:

a. To provide a course in *unified* mathematics, a course which interests pupils, in the best sense of the concept "interest";

b. To provide a course in which rationalization is characteristic, in contrast to the courses in the lower grades in which habituation is the chief characteristic;

c. To provide a course which will, in general, develop desirable "habits of thought, achievement, conduct, and expression." (Hanus)

In terms of organization, the improvements sought are:

a. To provide a course in *unified* general mathematics,—a course whose content is tied together naturally in some manner, a course which gives the learner a broad outlook over certain elementary parts of mathematics, without, at the same time, sacrificing the qualities of consecutiveness, and system, which have been and should continue to be prime qualities of a course in mathematics;

b. To retain arithmetic as the main subject matter for grades seven and eight, and modern algebra as the chief content for grade nine;

c. To make each grade carry on the work of the grade below, and prepare for that of the grade above.

What precedes is only a syllabus of ideas for a course in junior high school mathematics, each item of which could and should be elaborated. In a brief article, only a few can be elaborated.

Observe in this syllabus the emphasis upon arithmetic. Skill in computation must be attained and retained by pupils. There is a grave danger at this point however. Many courses of study give what seems an unwise amount of time to practice exercises in abstract computation. By the time children reach grades seven and eight, such practice begins to reach the stage of diminishing returns, and most certainly begins to be a bore to the pupils. At the beginning of grade seven, there is argument for

systematizing and rationalizing the pupils' knowledge of the fundamental processes, since that has not been done previously. As much as possible the necessary reviews of the fundamental processes should enter as by-products of other more worth-while subjects of study, especially in grade eight.

The maximum benefit from the study of arithmetic in these grades must come from the informational arithmetic. First of all, the pupils need training in solving problems. In the lower grades, they get an abundance of training in the abstract processes, and, often, an inadequate amount of training in solving problems. While solving the typical problems in the junior high school, they are made acquainted with the uses of arithmetic in various situations of life. No other part of mathematics is so rich in contacts with social, industrial and business practices,—in fact, no other school subject is as rich in these respects as is informational arithmetic. This type of arithmetic should be stressed in grades seven and eight, and should be carried over into grade nine, instead of bringing down into grade nine any demonstrative geometry or even numerical trigonometry. It is far more educative than either of these subjects for children of junior high school age. Some say that this arithmetic is "beyond the world of thought and interest" of the pupils. That is exactly the reason for teaching it,—namely to extend their world of thought and interest. It is time for the pupils to get away from the world of toys and dolls into the world of actuality in which we all live. To be sure, it must be the purpose of the junior high school course of mathematics to arrange this informational arithmetic in a graded course, and to teach it by methods which will enable the pupils to profit by the study of it, and which will bring out its mathematical value as well as its informational value.

There is reason, time, and place for instruction in geometry in the junior high school, intuitive geometry,—geometry studied by methods in which intuition and experiment, or induction play the principal role. There is valuable geometrical information which children should acquire, but thinking educators in all countries, as well as the experience of the race, have agreed that demonstrative geometry is unsuited for the first instruction for children. Intuitive geometry fills this need. Over a generation ago an effort was made to introduce it into the schools, but with little success. The failure was caused in part by lack of clear understanding of the purpose of the course, by faulty methods of instruction, and by unwise choice of subject matter.

As to purpose, intuitive geometry has practical value, pleasure value, and preparatory value,—and these are their order of importance. Its practical values are:

a. To develop knowledge of the fundamental geometrical concepts, terminology, notation and truths;

b. To train the hands in the use of the common drawing instruments, the straight edge, the square, the protractor, and, to an extent, the compasses;

c. To train the eye to see geometrical relations;

d. To train the mind in methods of studying geometrical data by inductive processes.

e. To give general training in desirable habits of thought, achievement, and conduct,—and one school man of wide experience has said that no other subject of the whole elementary curriculum will do it better.

Its pleasure value lies in the fact that, when the subject is taught by a teacher using skillful modes of instruction, the pupils do derive great pleasure from the study, while accomplishing all the practical purposes of the course.

Its preparatory value for the pupils who go into demonstrative geometry is beyond question,—provided temperateness has been observed in selecting the subject matter for the course in intuitive geometry. The mistake made years ago, and being made now in some cases, is that of trying to teach too much geometry. In doing so, the pupil is burdened, and the life of the course in demonstrative geometry is sapped in advance. All the real values of the course can be attained by a limited study of geometry. *The value depends chiefly on the methods and modes of instruction.* The most practical facts of geometry should be selected, first, and these, without question, are the mensuration theorems of plane and solid geometry for the more common figures, the manner of constructing some of these figures, and a few of the more common facts about them. With this should go instruction in the necessary concepts, terminology, and notation, to facilitate the instruction. The study of accurate constructions with compasses, of the ideas of congruence, similarity, symmetry, and numerical trigonometry have at best questionable value in the junior high school. In particular, intuitive geometry is not at all synonymous with constructional geometry; neither necessarily implies the other. Constructional geometry may indeed lack most of the qualities which a good course in intuitive geometry should possess.

There is reason, time, and place for study of literal arithmetic and the beginnings of algebra prior to grade nine. The use of literal numbers in formulas may be said to be so general now that knowledge of literal arithmetic may be regarded a part of elementary education, or of lower junior high school education. Literal arithmetic may be defined as algebra, without negative numbers,—or, positively, algebra of positive integers and fractions. The study of it is not difficult and does interest pupils. It correlates well with arithmetic, giving desirable training in computation; it is a step up in mathematical understanding—a step up from the level of particular numbers to the level of numbers in general.

These are good reasons for studying it before grade nine. How long before grade nine? A degree of temperateness will be wise here as in the case of geometry. Do not start everything in grade seven; keep something new for grade eight,—not to mention the fact that there is quite enough to do now in grade seven. There is place for the simplest possible use of the formula in grade seven. In grade eight, the study and use of the formula may, and should, be made the large undertaking of the grade. The mathematics of grade eight has been especially barren, more so than that of grade seven. By organizing it around the concept of the formula, dignity is given to it, and a new appeal is made to the interest of the pupils. To do it properly, and thus make the course contribute the maximum of mathematical education, it becomes necessary to teach certain ideas about the equation. All this can be done in two or three weeks of time early in grade eight, after which the formula and equation can be used and impressed during the balance of the year.

Toward the end of grade eight, there is argument for study of the beginnings of algebra. The pupils, at this time, are beginning to look to the "high school," even when they are already in a junior high school, and much more so when they are in an eighth grade class. They are getting "spring fever" in many cases. Algebra is particularly adapted to the needs of this situation. The children like it, and they can do it, notwithstanding all the current nonsense about not permitting children with low I. Q. to study algebra. Give them a chance. Even criminals are assumed not guilty in this country until they are convicted. Why convict children of incapacity to study algebra before they have tried the subject. Does it tie up with the rest of the work in grade eight? That depends upon what is done. Does it

prepare for grade nine? That also depends upon what is done. As in the cases discussed previously, temperateness is needed here. Not quantity but quality of instruction is important. Algebra has been a failure in eighth grade in many places—chiefly because the emphasis has been misplaced. A survey of the whole of first year algebra has often been attempted, and that is most pernicious. In the first place, quality of instruction under such circumstances is impossible, as the teacher in the ninth grade discovers when she receives the pupils. In the second place, the novelty of almost all the topics of the ninth grade course in algebra has been destroyed,—thus destroying one of the large opportunities of the ninth grade teacher and pupil. In general, this beginning work in grade eight should teach certain topics from the first part of algebra, from the modern point of view as to method; should teach them thoroughly, although using relatively simple examples, so that the pupils will carry over into grade nine some definite ideas, skill, and habits. Among these topics, there should be the simple equation, and its use in solving problems, and the concept of positive and negative numbers. Most emphatically, this last topic is not so difficult that it needs to be avoided until the middle of grade nine, as has been proposed. The pupils in grade eight can master it and enjoy doing so.

Reference has been made repeatedly to method and mode of instruction. By method, one refers to the manner of developing the subject; by mode, one refers to the manner of managing the class,—to such matters as supervised study, etc. Most of the success of the pupils and much of the value of the mathematics to them depends upon the methods and the modes employed by the teacher.

In the elementary grades, the memoriter method predominates; the pupils are shown how to perform a process, are given much practice, and are expected to develop habits. One of the large changes in instruction which should take place in the junior high school mathematics is that of developing in the pupils a feeling for the necessity of proofs for mathematical principles or truths. In these grades, development by induction is particularly effective. It becomes a unifying principle for the mathematics of these grades,—a most worthwhile one, since induction is the type of thinking which is most commonly employed in extending knowledge. Every topic taught in junior high school mathematics should be rationalized by induction. Unfortunately, all begin-

ning teachers, and many experienced teachers need instruction in the technique of an inductive lesson. Often the lessons in the text are properly taught, and in such cases, teachers, especially young teachers, ought to be encouraged to follow the book. Just to digress a moment, has not "following the book" been made too unpopular? At this time when experimenting with a new type of mathematics for these three grades, it is especially unwise to lacerate the book; it is far better to select a text which as nearly as possible suits the needs of the school, and then follow it.

Deductive thinking is exemplified best in demonstrative geometry. It is a higher type of thinking, calls for greater concentration, subordinates memory work, and, to be of great value, must be used independently in the solution of original problems. It has been proposed that demonstrative geometry be placed in the junior high school. This is contrary to the judgment of the mass of experienced teachers. The argument for placing it there is that pupils should be given the opportunity to "explore" this field of mathematics to determine their capacity for further study in it. The implication is that this be a brief exploration. There can be only one result from such a brief exploration, for the majority of pupils, under the conditions existing in this country; namely, failure to derive any real benefits, and, as far as diagnostic value is concerned, a thoroughly erroneous judgment as to the ability of many pupils. Many, less capable, require patient long continued teaching to attain any success in the subject. For such, the result of a brief period of study is likely to be a dislike for it, and, to many teachers, the temporary difficulty experienced by these pupils will be regarded sufficient evidence of incapacity to warrant the recommendation that such pupils be excused from taking geometry. The bearing of all this on junior high school mathematics is that it is unwise to do any demonstrative geometry in grade nine.

As to mode of instruction in junior high school mathematics,—a minimum of recitation (re-ci-tation) mode, and a maximum of active working in class is most likely to bring mastery of elementary mathematics,—and certainly there cannot be any question that mastery in some degree shall be attained, instead of mere contact, "for appreciation." New topics should be studied in class as class exercises, under the direction of the teacher, especially in grades seven and eight, and lower nine. They should be followed by various forms of drill exercises,—oral class drill, blackboard class drill, and finally an abundance of individual seat drill.

Whether to segregate pupils in sections on the basis of some sort of intelligence test, or diagnostic test, is in most schools an interesting but academic discussion, since there are not enough pupils usually to make sectioning possible or since administrative difficulties prevent placing pupils in the groups into which they would apparently belong. As a matter of fact, a much more profitable matter for discussion in all schools is the management of classes of unsegregated pupils, to the end that individual needs and capacities be met. In mathematics at least this is entirely possible, if classes do not exceed thirty pupils, if the teacher will endeavor to have a maximum of what has been called, above, individual seat drill. At such times, the pupils should be encouraged and helped to do all they can, no two doing, necessarily, the same amount. The teacher can pass about among them, giving guidance and suggestion as may be necessary. Some of the pupils will master in this way a block of material which earns for them only a rank of fair, others a rank of good, etc.

In closing, may it be remarked again, that a brief article, such as this, can give only a sketch of ideas which seem pertinent to the large subject, junior high school mathematics.

ELECTRIC EYE SEES STARS.

How the electric eye, the photo-electric cell that makes television possible, can be used for measuring the light of stars was explained by Dr. Joel Stebbins, of the Washburn Observatory at Madison, Wis.

"A star image is focused on such a cell by the telescope lens," he said, "and the resulting electrical current gives a measure of the amount of light received.

"One of the interesting objects studied is the star Epsilon in the constellation of Auriga, known to consist of a bright body and a larger faint companion which revolves around the main star in a period of twenty-seven years. During the six months since last June the darker body has been slowly moving in front until the bright star is now entirely obscured and we get only the light of the faint component.

"This total eclipse will continue for about a year, when the bright body will again begin to emerge, and after another six months the system will be of normal brightness. From the long intervals involved in these changes it follows that the companion must be an unusual body; it is a planet larger than its sun, so diffuse that its density cannot be more than one one-hundred-thousandth that of air, and yet it shines like a star. Some of the facts concerning this system have been known heretofore, but it is hoped to secure new data from the present eclipse which affords an opportunity not to be repeated for twenty-seven years."—*Science News Letter.*

WEIGHT, MASS AND THE DYNE.

By W. C. Hawthorne,

Crane Junior College, Chicago, Ill.

Why, oh, why do we continue to confuse our students in elementary physics by using the words pound and gram to signify sometimes WEIGHT and sometimes MASS. It should be obvious that with all the new ideas they have to assimilate, and the new ways of thinking they have to get accustomed to, that difficulties should not be needlessly multiplied. And the very idea of MASS is a difficult one to grasp. It comes only by deduction, as is pointed out by Nielson. (This journal, January, 1929, page 59. He would apparently make the "three fundamental units" *length*, *time* and *force*,—instead of *mass*.) On the other hand, a notion of FORCE has been in the mind of the student since babyhood. How unpedagogical to spend time and strength in "defining" a known thing in terms of the unknown! A little insistence, and he may be trained to think of WEIGHT as a force, similar in all respects to the forces exerted by his muscles, a stretched rubber band, a compressed gas, etc., and he has a way of comparing (measuring) all forces. But MASS!

For when we start with the DYNE as the standard unit of FORCE, and define it as "that FORCE that will give to a gram MASS" etc., we are stringing together in one sentence too many ideas for the beginner to integrate. I will not go so far as to say that no high school pupil can learn this definition, for there will be an immediate howl of protest from hundreds of teachers of high school physics. I will not even say that no high school pupil can understand the definition after he has learned it by rote. But I will say that after fifteen years of teaching college students, every one of whom has had, presumably, a year of high school physics, I have yet to find one who had more than the vaguest conception of what the word DYNE means. If he remembered having heard it at all, his invariable definition was, "That force that will move a gram one centimeter." And be it understood that I am confident that the vast majority of these young people had earnest, conscientious and capable instructors.

"But," comes the horrified protest from some teacher of physics, lovingly fondling the diploma that certifies to his Ph. D. in science, "how can we teach 'work' problems involving acceleration without the ideas of MASS, the DYNE and the POUNDAL?"

Bless your soul, my friend! The practical engineer has been

solving all these problems for years and never bothers his head about the definitions you are wasting your time upon. Say "MASS" to him and he immediately writes "W/g" and his answer comes out in units of force that everybody understands—pounds or grams. MASS to him, in other words, is merely a numerical expression. He may, of course, talk about "slugs" or "g-pounds" but never about a "one-pound mass."

"Ah, but we *must* teach our pupils something about the *dyne* of force, for all our electrical units are tied up with that quantity." I deny the compulsion, but if you do feel the urge, suppress it until you really need the definition, and then bring it in incidentally. If, when teaching dynamics, you have to use the dyne occasionally in deference to the text-book, give it as 1/980 of a gram-force, and the pupil will get along very nicely, thank you. When the bright boy of the class wants to know "how come" it may be all right, if you have the time, to explain the origin of the unit, but be merciful and don't expect all to remember what you have said. There are other things more important.

Do I hear an indignant chorus that "the gram is a unit of MASS and we always speak of it as a unit of MASS"? Ye-e-es, you do! Just as you always say "It is I"—when you know someone is watching you. I think I hear you calling out, when the pupils are checking up at the close of an experiment on (say) DENSITY, "Wait a moment, John! There's a ten gram MASS missing from this block of MASSES." Honestly now, do you? You call them WEIGHTS; the pupil knows them as WEIGHTS; (at least he doesn't speak of them as anything else) and in his mind, the piece of metal that is taken out of the "block of weights" measures the same thing that the spring balance does.

Why can't we omit all mention of mass until we have learned about the acceleration of gravity, and how the pull of gravity, and consequently the acceleration of gravity varies from place to place? But since they vary directly, "W/g" always gives the same quotient for the same body, no matter where it is in the universe. A name for this quotient is convenient. Let us call it MASS and restrict the use of the word to this expression. Then we shall no longer be bothered by the despairing cry "But I can't understand why we sometimes divide the weight by g and sometimes we don't!" The answer is "Always, when you want to use the expression MASS in a problem. Then the FORCE comes out in grams or pounds. If you want to express the FORCE in DYNES rather than in grams, multiply your answer by 980, or, what is

the same thing, omit the division in the first place."

After a while, they may be taught that this quantity, MASS, is also proportional to the inertness or stay-as-it-is-ness of matter when a FORCE acts upon it, so that the relation, $m = f/a = i$ is hooked up with what they have previously learned about MASS. And when the pupil learns further that it is this same quantity that remains unchanged through all the various operations that the chemist effects upon a piece of matter, he begins to attach a concrete meaning to what was at first only a mathematical expression. But when we start out by having him express MASS in the same units that he uses to measure FORCES we introduce complexities that the immature mind can't handle.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,

University of Oklahoma, Norman, Okla.

If the nose of Cleopatra had been shorter, the whole face of the earth would have been changed.—*Blaise Pascal, philosopher and mathematician, in "Thoughts."*

Science does not know its debt to imagination.—*R. W. Emerson.*

I should have liked to use the word "metaphysics" in the title of this book, but there are certain words which have accumulated such evil implications that they must either be abandoned, or withdrawn for a period of purification.—*Gilbert N. Lewis, chemist, in "The Anatomy of Science."*

We consider it tedious to talk of the weather, and yet there is nothing more important.—*Berthold Auerbach, novelist.*

Minds that are stupid and incapable of science are in the order of nature to be regarded as monsters and other extraordinary phenomena; minds of this sort are rare. Hence I conclude that there are great resources to be found in children, which are suffered to vanish with their years. It is evident, therefore, that it is not of nature, but of our own negligence, we ought to complain.—*Marcus Fabius Quintilianus, Roman rhetorician and critic.*

'Tis pleasing to be school'd in a strange tongue
By female lips and eyes—that is, I mean,
When both the teacher, and the taught are young,
As was the case, at least, where I have been;
They smile so when one's right; and when one's wrong
They smile still more.

—*Byron, "Don Juan."*

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
University of Michigan, Ann Arbor, Mich.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, 204 Mason Hall, University of Michigan, Ann Arbor, Mich.

LATE SOLUTIONS.

977. *Herbert Mjomid, Petersburg, Alaska.*
1033. *A. Vaidhyanadhan, Tanjovei, India.*
1035, 1036. *Douglas I. Bates, Portland, Oregon.*
1037, 1038, 1039, 1040, 1041, 1042. *J. F. Howard, San Antonio, Texas.*
1037. *J. Murray Barbour, Aurora, N. Y.; Paul Mount-Campbell, Vista, Col.*
1042. *J. Murray Barbour, Fred A. Lewis, University, Ala.*

SOLUTIONS OF PROBLEMS.

1043. *Editor.* This problem as it appears in the print is different from the form as intended by the *Proposer.* The correct form is *Problem.* 1061 in this issue.

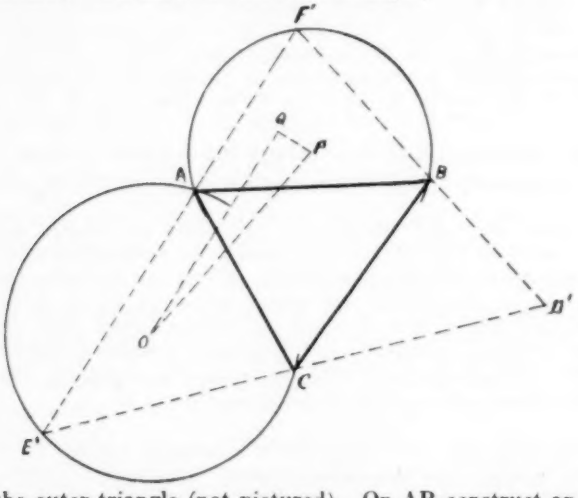
The result for the problem as it is now printed is $1^\circ = 1$.

1044. *Proposed by Michael Goldberg, Washington, D. C.*

Inscribe one given triangle in another given triangle.

I. *Solved by Howard Grossman, Brooklyn, N. Y.*

This problem is equivalent to the circumscribing of the second triangle about the first. Let ABC be the inner triangle;

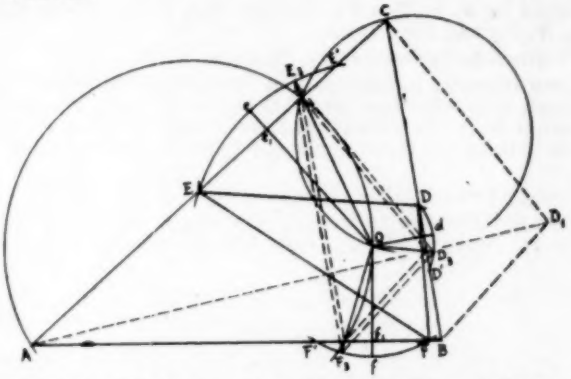


DEF is the outer triangle (not pictured). On AB construct an arc of a circle such that an inscribed angle will equal $\angle$F of DEF. On AC construct arc of circle such that an inscribed angle will equal $\angle$E of DEF. With line of centers of these circles, OP, as an hypotenuse, draw right triangle either one of whose arms, OQ = EF/2. Through A draw E'F' parallel to OQ. Draw E'CD', F'BD', then D'E'F' is the required triangle, and we may reverse the construction inscribing ABC in DEF.

Proof. If we draw perpendiculars on E'F' from O and P, then
$OQ = (E'A+AF')/2 = E'F'/2,$
$E'F' = EF.$
Since $\angle E' = \angle E$, and $\angle F' = \angle F$, D'E'F' is congruent to DEF.

II. *Solved by George Sergent, Tampico, Mexico.*

Let DEF be the triangle to be inscribed in ABC. Inscribe in ABC any triangle similar to DEF. This may be done by constructing outwardly on BC a triangle D_1CB similar to DEF, and drawing AD_1 which determines D_2 on BC. Parallels through D_2 to D_1C and D_1B determine E_2 on AC and F_2 on AB.



The circumcircles of the triangles AE_2F_2, BD_2F_2 and CD_2E_2 intersect in a common point O(wnich is the permanent "center of similitude" of all the triangles similar to DEF and having each of their vertices on the same side of triangle ABC as the corresponding vertex of $D_2E_2F_2$). Taking O as center of homothety, construct the triangle $D_3E_3F_3$ directly homothetic to $D_2E_2F_2$ and equal to DEF. Revolve OD_3, OE_3, OF_3 in the same direction aronnd O so that their exteremities fall on *a*, *b*, *c*, respectively, in D, E, F. If these points fall each between two vertices of ABC, the triangle DEF is inscribed in triangle ABC. The rotation can be clockwise or counterclockwise, thus giving two positions for each vertex. The auxiliary triangle D_1BC can have two positions on BC. In one of them, as in the figure $\angle D_1CB = \angle E$, the vertices E and E' fall on side *b*. In the other, symmetric of the first, $\angle D_1BC$ equals E, E and E' fall on side *c*. Two pivots, O, and by each pivot two positions of the triangle DEF can be determined. Similarly, each of the vertices E and F can be given two positions on side *a* $\angle E$ or $\angle F$ facing $\angle A$. Thus six different pivots, O, can be found, giving each two positions of the triangle DEF with its vertices on the sides of triangle ABC.

III. *Solved by George Sergent, Tampico, Mexico.*

Let DEF be the triangle to be inscribed in triangle ABC. *See figure for Solution II.* Assume that D shall fall on BC, E on AC, F on AB. On BC as a chord draw the arc containing $\angle(A+D)$; on AC the arc containing $\angle(B+E)$. From their intersection, O, draw the $\perp$s Od_1, Oe_1, Of_1 to the sides BC, AC, AB, respectively. Construct the triangle equal to the given triangle DEF and directly homothetic to triangle $d_1e_1f_1$, O being the center of homothety. With O as center, and taking Od, Oe, Of, successively as radius, draw arcs, either clockwise or counterclockwise, the first cutting BC in D, the second cutting AC in E, the third cutting AB in F. If D, E, F, fall each between two vertices of triangle ABC, then DEF is inscribed in ABC.

Note. The general problem is solved in Newton's Principia, as Lemma XXVI. The two solutions given are not translations or adaptations of Newton's solution.

Also solved by *J. F. Howard, San Antonio, Texas.*

1045. *Proposed by Secran.*

Obtain the real solutions of the following set of equations:

$$X^3+XY^2 = Y^3+X^2Y = 1.$$

Solved by Kenneth Ping, Superior, Arizona.

The first two equations may be written

$$X(X^3+Y^3)-Y(X^3+Y^3) = 0,$$

or

$$(X-Y)(X^2+Y^2) = 0.$$

Assuming that the factor (X^3+Y^2) is not zero, then $(X-Y) = 0$, and $X = Y$. Substituting Y for X in the original equations gives $X = Y =$ the cube root of 1/2.

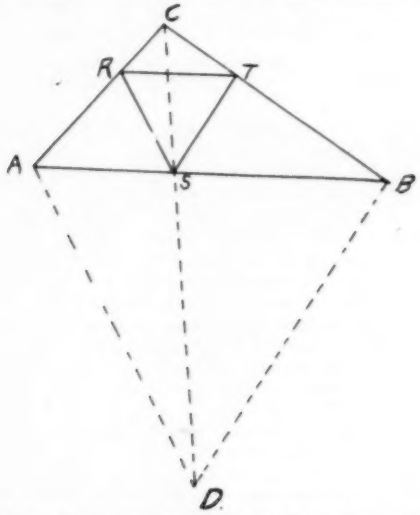
Also solved by *J. F. Howard, San Antonio, Texas; Howard Grossman, Brooklyn, N. Y.;* and the *Proposer.*

1046. *Proposed by Carlton Jencks, Spokane, Wash.*

Given any triangle: to construct an equilateral triangle so that one of its sides shall be parallel to a side of the given triangle, the extremities of this side are to lie in two sides of the given triangle and the vertex opposite this side is to lie in the remaining side (or the side extended) of the given triangle.

Solved by C. Lester McKee, Hartville, Ohio.

Construction. Exterior to triangle ABC, upon AB as a side, construct an equilateral triangle ABD. Draw CD intersecting AB at S. Draw



ST parallel to BD and RS parallel to AD; draw RT. Then RST is the required triangle.

Proof. For triangle CBD.

$$CT/TB = CS/SD.$$

For triangle CAD

$$CR/RA = CS/SD.$$

Hence

$$CT/TB = CR/RA,$$

and RT is parallel to AB. Then triangle RST is equilateral having three sides respectively parallel to three sides of the equilateral triangle ABD.

Also solved by *Howard Grossman, Brooklyn, N. Y.; George Sergent, Tampico, Mexico; J. F. Howard, San Antonio, Texas; Rudolph Jandl, David Bowman, Spokane, Wash.;* and the *Proposer.*

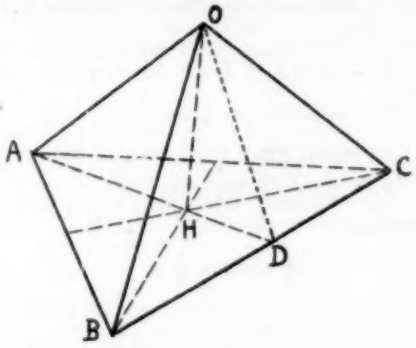
1047. *Proposed by J. F. Howard, San Antonio, Texas.*

Given O−ABC a tetrahedron with tri-rectangular trihedral angle at O. Prove that the square of the area of face ABC equals the sum of the squares of the areas of faces AOB, BOC and AOC.

I. *Solved by George Sergent, Tampico, Mexico.*

We shall first prove that the square of the area of a face is the mean proportional between the area of its projection on the base and the base.

Draw through OA the plane $\perp$ to BC; it is $\perp$ to the base ABC and therefore contains the altitude OH of the tetrahedron. Let AD be the intersection of this plane with the base.



We have OA $\perp$ OD, OD $\perp$ BC, AD $\perp$ BC, and OH $\perp$ AD.
In the right triangle AOD we have

$$(OD)^2 = (AD)x(HD) \qquad (1)$$

Since the triangles BOC, BAC and BHC have the same base BC, the relation of their areas is the same as that of their altitudes OD, AD, and HD. Hence by (1) we have

$$(BOC)^2 = (BAC)x(BHC). \qquad (2)$$

Similarly,

$$(BOC)^2 = (BCA)x(BHA), \qquad (3)$$

$$(AOC)^2 = (ABC)x(AHC). \qquad (4)$$

Adding, we get

$$(BOC)^2+(BOA)^2+(AOC)^2 = (ABC)\,(BHC+BHA+AHC) = (ABC)^2$$

II. *Solved by Robert Hechtman, Spokane, Wash.*

Let OA = a, OB = b, OC = c, AB = X, BC = Y, AC = Z, and K equal the area of the base ABC. Then $X^2 = a^2+b^2$, $Y^2 = b^2+c^2$, $Z^2 = a^2+c^2$. Substituting the values of X, Y and Z in

$$K^2 = S(S-X)\,(S-Y)\,(S-Z)$$

and in turn substituting the values of X, Y and Z in terms of a, b and c, respectively, we get after simplifying

$$K^2 = \frac{a^2b^2+b^2c^2+a^2c^2}{4}.$$

Also solved by *R. T. McGregor, Elk Grove, Calif.; Norman Anning, Ann Arbor, Mich.; A. E. MacNeish, Chicago, Ill.;* and the *Proposer.*

1048. *Proposed by S. W. Hockett, Oskaloosa, Iowa.*

Give a solution of the following set of equations which is suitable for High School Students:

$$X^3+Y^3 = 13 \qquad (1)$$

$$X^3+Y^3 = 35 \qquad (2)$$

Solved by L. Wayne Johnson, Norman, Okla.

Equation (1) may be written

$$(X+Y)^3 = 13+2XY \qquad (3)$$

Equation (2) may be written

$$(X+Y)\,(13-XY) = 35 \qquad (4)$$

Eliminate XY from the equations (3) and (4) we get

$$(X+Y)^3-39(X+Y)+70 = 0. \qquad (5)$$

By inspection we see that (X+Y) = 2. Divide the left member of (5) by [(X+Y)−2], the depressed equation is

$$(X+Y)^2+2(X+Y)-35 = 0.$$

The following solutions of (3) and (4) are easily obtained:

$$\left\{\begin{matrix} X+Y=5 \\ XY=6 \end{matrix}\right\}, \quad \left\{\begin{matrix} X+Y=-7 \\ XY=18 \end{matrix}\right\}, \quad \left\{\begin{matrix} X+Y=2 \\ XY=-9/2 \end{matrix}\right\}.$$

These three systems in turn yield four real and two imaginary pairs of values which satisfy equations (1) and (2).

Also solved by *Howard Grossman, Brooklyn, N. Y.; Earl Babbitt, Whitney, Neb.; M. W. Coultrap, Naperville, Ill.; R. T. McGregor, Elk Grove, Calif.; J. F. Howard, San Antonio, Texas; Norman Anning, Ann Arbor, Mich.;* and the *Proposer.*

Editor. Several of the solutions used the substitutions $X+Y=U$ and $XY=V$, or $X=U+V$ and $Y=U-V$, all of which reduced to the same general form.

PROBLEMS FOR SOLUTION.

1061. *Proposed by R. T. McGregor, Elk Grove, Calif.*

Restatement of 1043. Without using the Calculus evaluate for $A=90°$ the following expression:

$$\left(\text{cosec } A\right)^{\tan^2 A}.$$

1062. *Proposed by E. de la Garza, Brownsville, Texas.*

Restatement of 1025, as intended by the Proposer.

Given a triangle ABC, to draw a line DE, limited by the sides of angle A, such that DE = DB = EC, D being on AB.

1063. *Proposed by Norman Anning, Ann Arbor, Mich.*

Show that the cubic equation

$$(\ )X^3+(\ )X^2+(\ )X+(\ )=0,$$

where the gaps are filled by some arrangement of the numbers 0, 1, 2, −3, always has a rational root. Of what general theorem is this a special case?

1064. *Proposed by A. J. Paterson, Wheeling, W. Va.*

A tree standing on a slope, having a rise of 11 feet to 61 feet on the slope, breaks so that the top may strike the ground 61 feet up from the base, and $48\frac{1}{6}$ feet down from the base. Find the height of the tree.

1065. *Proposed by the Editor.*

Using only a ruler, draw through a point external to a circle the two tangents to the circle.

1066. *Proposed by the Editor.*

Using DeMoivre's theorem for powers of complex numbers, prove the following relations:

$$\text{Sin } 3A = 3 \sin A - 4 \sin^3 A,$$
$$\text{Cos } 3A = 4 \cos^3 A - 3 \cos A.$$

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

To Readers of School Science and Mathematics:

You are invited to propose questions for solution or discussion.

You are asked to answer questions.

Examination papers are always desired, send in your own papers or any others. Some are interested in college entrance examinations, others in school or college examinations. All are desired.

Please address all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E., Cleveland, Ohio.

QUESTIONS FOR SOLUTION AND ANSWER.

General Information in Science.

530.

The following questions were given in the science section of "general information" test at University School.

Try it with your own pupils and report interesting answers and percentage standings.

V.—Science, Invention, etc.

a. Why does iron float in mercury?
b. When it is 9 a. m. in New York, what time is it in San Francisco?
c. Who made the first telescope?
d. How many chemical elements are now known?
e. What metal is the best conductor of electricity?
f. What is the derivation of the word "biology"?
g. Where is the radio station WEAF located?
h. What is the formula for finding the cubical contents of a cylinder?
i. What is the derivation of the word "hydrometer"?
j. What is meant by the term "33x6.00 tire"?

TEST QUESTIONS.

531. *Questions from Harry E. Williams, Ironton High School, Ironton, Ohio.*

(On account of limited space in this department of School Science these questions will be published in instalments. All told there are 100 questions in the examination paper. The first 61 questions only are published in this number.)

Try out these questions on your own class and write your report to the Editor.

Send your own examination paper.

Ironton, Ohio, Jan. 28, 1929.

Mr. Franklin T. Jones,
10109 Wilbur Ave., Cleveland, Ohio.

Dear Sir:

I have seen your requests in SCHOOL SCIENCE AND MATHEMATICS for tests and examination questions and am sending a copy of our semester examination in Physics given Jan. 16, 1929. This covers our work for the semester over the following conventional topics: metric system, simple machines, mechanics of liquids and gases, force and motion, falling bodies, expansion and transmission of heat. The maximum time allowed was two hours though all had completed the examination in about one and one-half hours. The first 61 questions are of the completion type, the next 9 are problems, the next 2 are drawings, No. 73 a multiple choice, the next 7 are of the generalization type, the last 20 are single choice questions. Some of the questions may be answered in several ways but most of them have a definite answer.

Very truly yours,

HARRY E. WILLIAMS,
Physics Instructor, Ironton High School.

SEMESTER EXAMINATION—PHYSICS.

Ironton High School, Jan. 16, 1929.

The examination covers the following topics: metric system, simple machines, mechanics of liquids and gases, force and motion, falling bodies, expansion and transmission of heat.

Fill in the word or group of words that make the statement true:

1. One inch—.....cm.
2. One meter—.....cm.
3. One meter—.....inches.
4. 1 cu. cm. of water weighs.....grams.
5. 1 cu. ft. of water weighs.....lbs.
6. 1 kg.—.....grams.
7. Density—.....divided by.....
8. A clock loses time; its pendulum should be.....
9. The name of the force which causes objects to fall toward the center of the earth is.....

10. The tendency of a body to retain its position of rest or of motion is called.....
11. That force which manifests itself in the tendency of a rotating body to fly out from the center of rotation is call.....
12. The loss of weight of an object immersed in a liquid is equal to the weight of.....
13. The instrument used to measure the pressure of the atmosphere is called a.....
14. The instrument used to test the gravity of storage battery solutions is called a.....
15. The separation of cream from milk by the use of the cream separator is an application of.....
16. Specific gravity-weight of solid divided by weight of.....
17. The Magdeburg hemisphere experiment shows that the atmosphere has.....
18. Standard atmospheric pressure is.....lbs. per sq. in.
19. At standard atmospheric pressure the barometer registers..... in; .....cm.
20. A falling barometer usually indicates.....
21. Boyles Law states that at constant temperature the volume of a gas varies..... as the.....
22. The principle underlying the action of the hydraulic press was stated as a law by.....
23. The force of attraction between molecules of the same kind is called.....
24. The surface of a liquid acts like a stretched elastic membrane, which contracts whenever it can. This tendency is called.....
25. Mercury will not rise in exhausted tubes as high as water will rise because.....
26. A barometer registers less on the top of a mountain than at the foot because.....
27. The specific gravity of gold is 19.3. Its density is..... grams per cu. cm.
28. The overcoming of resistance is called.....
29. The efficiency of a machine is always less than.....per cent.
30. The work done per unit time is called.....
31. The ratio of the work got out of a machine to the work put in is called the..... of the machine.
32. The resistance which opposes the pulling of a block of wood along the floor is called.....
33. Energy that an object has because of its position or state of strain is called.....energy.
34. The mechanical advantage of any simple machinel equals..... divided by.....
35. The mechanical advantage of the inclined plane in terms of its parts equals.....
36. The mechanical advantage of a system of pulleys is found by .....
37. Perpetual motion will not work because of.....
38. A single fixed pulley has a mechanical advantage of.....
39. A single movable pulley has a mechanical advantage of.....
40. Work—..... times.....
41. A common use of the lever is.....
42. A common use of the inclined plane is.....
43. The point on an object where we can consider the weight concentrated is called the.....
44. Two units of measuring work are
    a..... b.....
45. If a person displaces his own weight of water, it is possible for him to.....
46. Part of the energy applied to a machine is lost because of .....

47. Energy that a ball has when rolling along a level ground is .....energy.
48. Compressed air is used in.....
49. One practical illustration of capillary action is the rising of .....
50. At a given depth in a liquid, the downward, upward and sidewise pressures are.....
51. Weighing an empty flask, pumping air into it and weighing again shows that.....
52. The method by which the sun transmits heat to the earth is called.....
53. The name of the process by which heat is carried from one place to another by a moving fluid is.....
54. The usual form of thermometer is based on the principle that liquids when heated.....
55. The two fixed points on a liquid thermometer are..... point and.....point.
56. The expansion of a unit length of a substance for one degree rise in temperature is called the.....
57. Four solids that are good conductors of heat are..... .....
58. Four solids that are poor conductors of heat are..... .....
59. Absolute zero is..... degrees Centigrade.
60. One practical house-hold use of the vaccuum pump is the .....
61. Wooden handles are often used on cooking utensils because .....

BOOKS RECEIVED.

A Synthesis and Evaluation of Subject-Matter Topics in General Science by Francis D. Curtis, Associate Professor of Secondary Education and of the Teaching of General and Biological Science, University of Michigan. Cloth. 83 pages. 15x23 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.00.

A History of Physics by Florian Cajori, Professor of the History of Mathematics in the University of California. Revised and enlarged edition. Cloth. Pages xiii+424. 13x20 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price $3.50.

College Algebra by Bolling H. Crenshaw, Head Professor of Mathematics, Alabama Polytechnic Institute and Duncan C. Harkin, Associate Professor of Mathematics, Alabama Polytechnic Institute. Cloth. Pages xiii+224. 13x19.5 cm. 1929. P. Blakiston's Son & Co., 1012 Walnut Street, Philadelphia. Price $1.75.

The Radio Manual by George E. Sterling, Radio Inspector, Radio Division, U. S. Department of Commerce Member, Institute of Radio Engineers, and Edited by Robert S. Kruse, formerly Technical Editor QST. Magazine of American Radio Relay League; Consultant for Development of Short Wave Devices, Technical Editor and Writer. Third Printing. Cloth. Pages v+666. 13.5x20 cm. 1928. D. Van Nostrand Company, Inc., 8 Warren Street, New York. Price $6.00.

Ninth Grade Mathematics by Flora M. Dunn, Head of Mathematics Department, Fairfax High School, Los Angeles, California, Emmy S. Huebner, Teacher of Mathematics, Fairfax High School, Los Angeles, California, and John S. Goldthwaite, Head of Mathematics Department, Lincoln High School, Los Angeles, California. Cloth. Pages viii+290. 12.5x18.5 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.20.

Chemistry in Everyday Life by Frederic B. Emery, Harrison Technical High School, Elzy F. Downey, Crane Technical High School, Roscoe E. Davis, Lane Technical High School and Charles E. Boynton,

Waller High School, all of Chicago. Cloth. Pages xv+719+xlvii. 13x18.5 cm. 1928. Lyons and Carnahan, Chicago.

First Course in Algebra by W. H. Williams, Head of the Department of Mathematics, State Teachers College, Platteville, Wisconsin, Formerly Instructor in Mathematics, Oak Park High School, Oak Park, Illinois, and Mona Dell Taylor, formerly Head of Department of Mathematics, Scott High School, Toledo, Ohio, and Instructor in Mathematics, West Technical High School, Cleveland, Ohio. Cloth. Pages iv+379. 12x18.5 cm. 1929. Lyons & Carnahan, Chicago.

Applied Chemistry, A Laboratory Manual for Elementary Students by Frederic B. Emery, Harrison Technical High School, Chicago, Elizabeth W. Miller, College of Education, University of Chicago and Charles E. Boynton, Waller High School, Chicago. Cloth. 120 experiments and A Method of Analysis 65 pages. 19x27 cm. 1928. Lyons and Carnahan, Chicago.

Annual Report of the General Education Board 1927-1928. Paper. Pages ix+54. 13.5x21.5 cm. 1928. General Education Board, 61 Broadway, New York City.

Bulletin of High Points in the Work of the High Schools of New York City by John L. Tildsley, District Superintendent of High Schools. Vol. X. No. 8. October, 1928. Paper. 186 pages. 15x23 cm. Copies may be had free by writing to the High School Department, Board of Education, 500 Park Avenue, New York.

A Short Table of Integrals by B. O. Peirce, Hollis Professor of Mathematics and Natural Philosophy in Harvard University. Third Revised Edition. Cloth. 156 pages. 13.5x20.5 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.48.

The Nature and Meaning of Teaching by Ralph F. Strebel, Assistant Professor of Education, Teachers College, Syracuse University. and Grover C. Morehart, Associate Professor of Education, Teachers College, Syracuse University. First Edition. Cloth. Pages xix+273. 13.5x20.5 cm. 1929. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $2.50.

Enriched Teaching of Science in the High School, A source book for teachers of General Science, Biology, Physics, Chemistry, and other sciences, listing chiefly free and low cost illustrative and supplementary materials by Maxie Nave Woodring, Associate Professor of Education, Teachers College, Columbia University, Mervin E. Oakes, Assistant in Natural Sciences, Teachers College, Columbia University and H. Emmett Brown, Teacher of Science, Lincoln School, Teachers College, Columbia University. Cloth. Pages xi+374. 15x23 cm. 1928. Bureau of Publications, Teachers College, Columbia University, New York City.

The Commonwealth Teacher-Training Study directed by W. W. Charters, Professor of Education, The University of Chicago and Douglas Waples, Professor of Educational Method, Graduate Library School, The University of Chicago and Introduction by Samuel P. Capen, Chancellor, The University of Buffalo. Cloth. Pages xx+666. 15x23 cm. 1929. The University of Chicago Press, Chicago, Illinois. Price $4.00.

Reference Book of Inorganic Chemistry by Wendell M. Latimer, Associate Professor of Chemistry in the University of California and Joel H. Hildebrand, Professor of Chemistry in the University of California. Cloth. Pages viii+412. 14x21.5 cm. 1929. The Macmillan Company, New York.

State of Connecticut State Geological and Natural History Survey, Bulletin No. 43. The Life Forms of Connecticut Plants and Their Significance in Relation to Climate by Beulah Ennis, Instructor in Botany, Wellesley College. Pamphlet of 100 pages with 20 plates. 14.5x22.5 cm. 1928. Hartford, Published by the State. Price 75 cents.

Tables of Damped Vibrations by W. E. Milne, Professor of Mathe-

matics, University of Oregon. Paper. 39 pages. 17x25 cm. 1929. University of Oregon, University Press, Eugene, Oregon.

Controlled Experimentation in the Study of Methods of College Teaching by Harl R. Douglass, Professor of Education and Others, University of Oregon. Paper. 52 pages. 17x25 cm. 1929. University of Oregon, University Press, Eugene, Oregon.

BOOK REVIEWS.

College Algebra, by J. C. Palmer, Professor of Mathematics and Dean of Students, Armour Institute of Technology, and W. L. Miser, Professor of Mathematics, Vanderbilt University. Pages xiv+377. 13.5x19 cm. 1928. New York: McGraw-Hill. Price $2.50.

This book is a conservative treatment of college algebra. The introductory chapters present matter of an elementary character to be used by students of mediocre ability or of limited high school training in algebra. There are two chapters which give some attention to the notion of functionality. There are numerous exercises and problems. J. M. Kinney.

An Introduction to Linear Difference Equations, by Paul M. Batchelder, Adjunct Professor of Pure Mathematics, the University of Texas, published with the cooperation of the National Research Council. Pages vii+209. 16x24 cm. 1927. The Harvard University Press, Cambridge, Mass.

This book aims to provide the student with an introduction to the theory of Linear Difference Equations, a field of mathematics which has received a great deal of attention in recent years. It is designed for the student who has had some training in the elements of the theory of Functions of a Complex Variable. J. M. Kinney.

Modern Physics by Charles E. Dull, Head of Science Department, West Side High School, Newark, New Jersey. Cloth. Pages viii+778. 12x18.5 cm. 1929. Henry Holt and Company, New York.

Modern Physics is a new textbook of high school physics to replace the text written by Mr. Dull a few years ago. He has followed the usual method of dividing the subject into the main divisions; viz., mechanics, heat, sound, light, magnetism and electricity, and has discussed them in the order given here. Following the introductory chapter on measurement is the treatment of the mechanics of fluids thus leaving the more difficult topics of force and motion for later chapters—the order now seemingly accepted for high schools. Each chapter starts with a vocabulary of new or technical terms with definitions. The author has consistently followed the plan stated in the preface of using (1) familiar introductory illustrations or historical references, (2) the statement and explanation of the principle, and (3) practical applications. The type is uniform in size for all topics thus leaving the teacher or student free to place the emphasis, except that definitions and principles are set in italics. Each chapter ends with a summary, a list of questions and usually a set of problems.

G. W. W.

Electrical Engineering Laboratory Practice by Oskar E. Edison, Associate Professor of Electrical Engineering in the University of Nebraska, and Ferris W. Norris, Associate Professor of Electrical Engineering in the University of Nebraska. Cloth. Pages ix+276. 14.5x23 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $2.80.

This laboratory manual includes eighty experiments nearly equally divided between direct and alternating current work, and ranging in difficulty from experiments on resistance of conductors in the first chapter to a study of synchronous machinery and induction motors in the latter part of the book. The plan followed throughout is a state-

ment of the object of the experiment, a reference to some standard text, a list of apparatus needed, a discussion of the method, a study of results such as directions for curve plotting and a list of questions. Wiring diagrams are given where needed and many theory paragraphs with diagrams are included. The Appendix contains the treatment for electrical shock issued by the National Electric Light Association and two wires tables. G. W. W.

Mineralogy, an Introduction to the Study of Minerals and Crystals by Edward Henry Kraus, Professor of Crystallography and Mineralogy and Director of the Mineralogical Laboratory, University of Michigan and Walter Fred Hunt, Professor of Petrology, University of Michigan. Second Edition. Cloth. Pages ix+604. 14x23 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York. Price $5.00.

The authors introduce the student to the subject of mineralogy by means of a few pages on its content, historical development and its relation to other sciences and to human activity. The body of the text is divided into five major sections. In the first of these, geometrical crystallography, six crystal systems are recognized and described, the description being supplemented by diagrams, pictures and charts. The second section gives the physical properties which are important in the rapid determination of minerals. This section also includes a brief but very clear discussion of polarized light and the polarizing microscope and also a chapter on crystal structure and x-ray analysis. Chemical mineralogy is the third major division, which includes chapters on chemical properties, formation and occurrence of minerals, and quantitative blowpipe methods. Section four is descriptive mineralogy. Minerals are grouped according to chemical composition and the principle of isomorphism, the simplest ones being discussed first. Nine classes are recognized. One hundred fifty minerals are described, the hundred most important ones being designated by bold-faced capitals and the fifty less important ones in small type. Another chapter gives a classification according to elements. This chapter is made up of an outline and brief description of the minerals with page references to the detailed description given in the previous classification. The section also includes a chapter on gems and precious stones. The fifth section consists of 167 pages of tables for the determination of the 150 minerals described in the text by a study of their physical properties, occurrence and associates.

Although prerequisites for the study of mineralogy are geometry, physics and chemistry, the authors do not assume that the student has a complete working knowledge of the details of these subjects, but have included in the text such topics as finding specific gravities by the Jolly and Westphal balances, the use of the polarizing microscope and of the blowpipe. The book is profusely illustrated with diagrams and photographs, a total of 766 illustrations. Interesting historical material is included to give the student some acquaintance with the scientists who have developed the subject and the methods they used. G. W. W.

EIGHT MOUNTAIN LIONS.

Chief Ranger Donal J. Jolley of Zion National Park recently surprised a group of eight mountain lions up on the east rim of Zion Canyon, coming as close as 40 feet to some of the animals before he saw them. The ranger was quite as surprised as the lions, which lost no time in disappearing into the thick brush.

Superintendent E. T. Scoyen of Zion Park, who has spent practically all of his life in one national park or another, states that he has never yet seen a mountain lion running at large. He considers Mr. Jolley's experience in meeting not one but several of them very unusual.—*Science News-Letter.*

ANCIENT PLANTS IN PACIFIC ISLANDS.

Seeds of American plants, or parts of plants with the seed still clinging to them, probably made a long emigrant voyage southward by water millions of years ago, and their decendants are still growing in the islands of the South Seas.

This is the picture presented by Dr. Forest B. H. Brown, botanist of the Bernice P. Bishop Museum of Honolulu, as a result of his studies on plants of the dogwood family growing in the Marquesas and neighboring islands. The route would be impossible today, for ocean currents do not set southward from the Gulf of Mexico, and Central America and the Isthmus of Panama bar the way into the Pacific. But during Cretaceous times, when dinosaurs still walked the earth, there was open sea where the land link now binds the continents together, and Dr. Brown is of the opinion that much seed-bearing plant material then drifted down the Mississippi, across the Gulf, through this strait and so into their great adventure southward.

Such a voyage route would account, in the opinion of the Hawaiian botanist, for the presence on the island of Rapa of the plant known as Lautea, which is a primitive relative of the American dogwoods and the only representative of its family ever found in the South Pacific islands. The American members of the family that stayed at home have evolved into more advanced forms, but fossils have been found in New Jersey that prove the presence of Lautea-like forms here some forty millions of years ago.

Associated with this far-from-home dogwood, Dr. Brown reports, are other primitive plants, including a creeping fern, which are abundantly represented in American fossil beds of Cretaceous age, distributed all the way from Greenland to the Gulf of Mexico.—*Science News-Letter.*

Modern, Simple, Systematic and Practical

Plane Geometry

BY LEONARD D. HAERTTER

THIS practical Plane Geometry textbook for high school courses offers a simple, systematic and logical course. It has numerous distinctive features. Chief among these are a definite plan for each proof, a great variety of exercises, new-type tests, summaries and reviews, supplementary material from solid geometry, and an abundance of figures and illustrations. The appendices contain a list of the axioms, a list of the symbols and abbreviations used in the text, and a list of formulas. The book presents the theorems recommended by the National Committee on the Reorganization of Mathematics in Secondary Education, as well as the theorems required by the College Entrance Examination Board.

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Please mention School Science and Mathematics when answering Advertisements.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, 28TH ANNUAL MEETING.

The annual meeting of the Central Association of Science and Mathematics Teachers held on November 30, and December 1, 1928, at the University of Chicago marks the end of a progressive year. The work of the year is conspicuous because of the acquisition of the journal, SCHOOL SCIENCE AND MATHEMATICS. This magazine, which has been the official organ for many years was purchased from Charles M. Turton and Glen Warner, and is now owned and published by the Association. For the work involved in this transaction, we are chiefly indebted to the President, and to the journal committee: T. O. Cantwell, H. R. Smith, and L. E. Hildebrand.

We looked forward with enthusiasm to this annual meeting. We knew that there would be interesting addresses, and that there would be friends to greet, and exhibits to view. The Friday morning program began at 9:15 o'clock. This session proved both inspirational and educational. The program was as follows:

Organ recital, James W. Hoge, Organist for the Laboratory Schools, The University of Chicago.

Address of welcome, Prof. Elliot R. Downing, The University of Chicago.

Response for the association, L. E. Hildebrand, New Trier High School, Winnetka, Ill.

Preliminary Report: The Purposes and Plans of the Incorporated Association, Ada L. Weckel, Member of the Board of Directors.

Address: Prof. Otis W. Caldwell, Columbia University, Subject: Some of the Next Steps in Science Teaching.

Address: Prof. Louis C. Karpinski, University of Michigan, Subject: Mathematics and the Progress of the Sciences.

These addresses by Prof. Caldwell and Prof. Karpinski had an appeal for everyone present, and are reported only in terms of high praise and approval.

The superior quality of the section programs held on Friday afternoon contributed much to the strength and excellence of the conference. The only regret was that one could not attend two or three of these meetings at the same time. Many of the papers, however, will appear later in the journal, SCHOOL SCIENCE AND MATHEMATICS.

On Friday evening a large number attended the annual reception and dinner held in Ida Noyes Hall. Eight past presidents were present. The after-dinner speaker on this occasion was John Mills, Director of Publications, Bell Telephone Laboratories, New York City. His subject was, Electrical Eyes and Their Use in Communication. This was a fascinating address and a fitting ending to the day.

For the success of this annual meeting we are indebted to many: to the speakers; to the section officers; to the general officers, and especially to the president; to the members of each committee, and particularly to Miss Ada Weckel, chairman of the membership committee, and to Mr. O. D. Frank, chairman of the committee on local arrangements. We wish, too, to express our indebtedness to the University of Chicago for this excellent place of meeting, and for the many courtesies extended.

Respectfully submitted,

WINNAFRED SHEPARD.

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ANNUAL BUSINESS MEETING, CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC., UNIVERSITY OF CHICAGO, DEC. 1, 1928.

The meeting was called to order by the president, 8:00 a. m.

The president read a report. On motion it was accepted, a quorum being present.

The secretary read a report which was accepted by motion and placed on file.

The treasurer read a report which was accepted by motion and placed on file.

The journal committee made a report, on motion accepted.

The Necrology committee read a report. On motion it was accepted and placed on file.

The membership committee read a report. On motion it was accepted.

The committee on professional training read a report which was accepted, placed on file and the committee continued.

The committee on resolutions read a report which was adopted by motion, except that by amended motion the election of Prof. Karpinski to honorary membership was referred to the Board of Directors for further action.

Reports of the auditing committees of treasurer's books and business manager's books were read and on motion were approved.

The chairman of the nominating committee, when his report was called for, made a motion for the change of Article IV, Sec. 2 of the By-Laws of the Corporation to wit: That there be twelve directors, four to be elected each year. The President being absent, the acting secretary presented the motion to the house. The motion prevailed by unaminous vote.

At the renewed request, the chairman of the committee presented a partial report on nominations for the ensuing year: For President, Miss Ada Weckel (no written report received); for Vice-President, W. G. Gingery; Directors: 3 year term, Jerome Isenbarger, H. R. Smith, Chas. Turton, W. F. Roeker; 2 year term, J. H. Smith, Glen Warner, Walter Hart, Frances Church; 1 year term, Jos. Nyberg, DeForrest Ross, Clyde Krenerick, M. J. W. Phillips.

On motion the report given was adopted and candidates were declared elected.

Adjournment.

H. R. SMITH, *Assistant Secretary.*

TREASURER'S REPORT, CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Money received between Nov. 24, 1927, and Nov. 17, 1928:

Memberships	$1759.50	Paid out:	
Exchange	.75	Subscriptions	$1310.00
Advertising	684.68	Printing	676.28
On hand Nov. 24, 1927	756.49	General	677.33
Total	$3201.42	Total	$2663.61
Balance on hand Nov. 17, 1928			$ 537.81

Money paid out between Nov. 24, 1927, and Nov. 17, 1928:

Subscriptions to SCHOOL SCIENCE AND MATHEMATICS $1,310.00

Lectures:

The University of Wisconsin
Summer Session 1929

General Session, July 1 to August 9
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Special Graduate Courses, July 1 to August 30
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Law School, June 24 to August 30
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Synonyms
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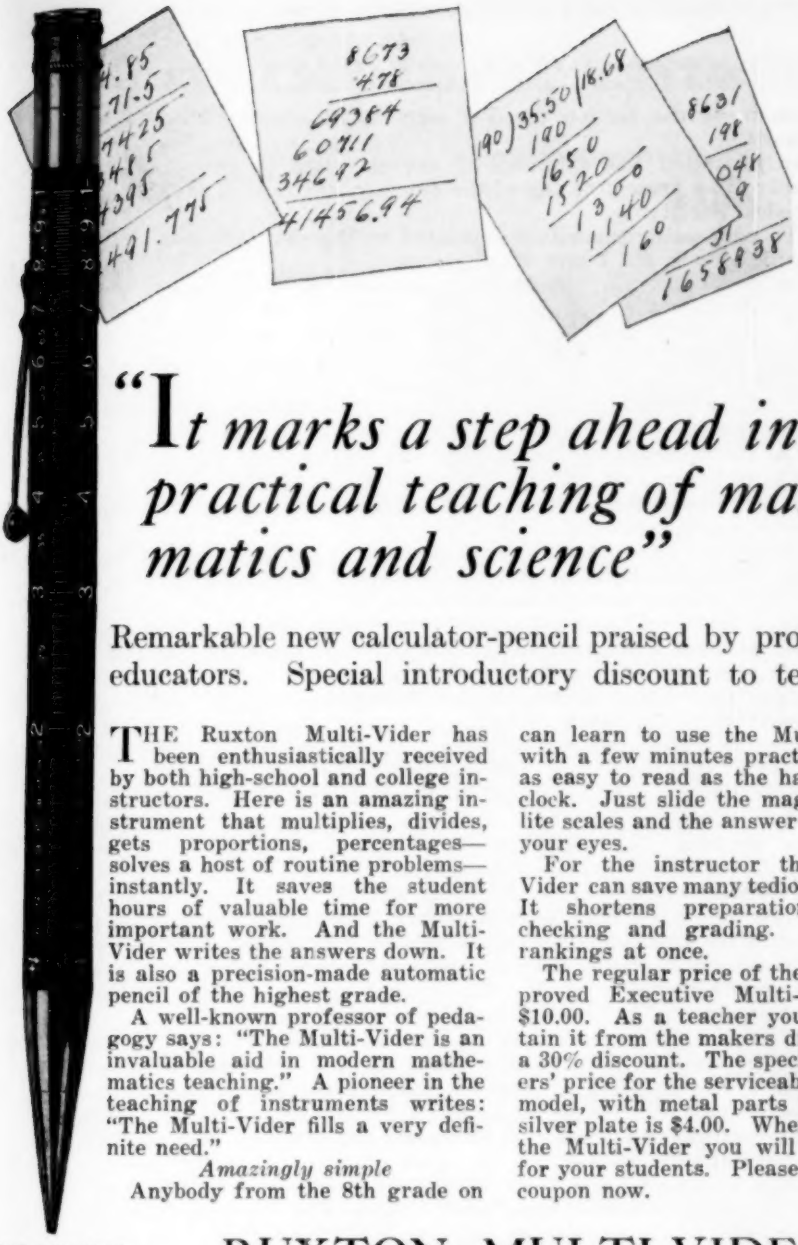
American Physical Society
Washington Meeting, April 19 and 20, 1929

William Hobbs	$50.00	
Charles Judd	50.00	
Henry Cowles	50.00	
W. D. McMillan	50.00	200.00
Local expenses, Detroit meeting:		
Struble local committee	$13.50	
Use of Building	30.00	
Badges	61.06	
Geog. Section	3.00	107.56
Year Book:		
Printing and mailing	$575.23	
E. R. Breslich, committee	55.10	630.33
Presidents' expenses:		
E. R. Breslich	$51.00	
W. F. Roecker	19.75	70.75
Secretary's expenses:		
Winnafred Shepard	$13.47	13.47
Treasurers' expenses:		
W. G. Gingery (stipend)	$50.00	
E. S. Martin (stamps)	10.00	
E. S. Martin (envelopes)	21.72	81.72
Membership Committee:		
W. F. Roecker	$57.14	
Ada K. Weckel	32.26	89.40
Printing:		
Regal Press	$ 7.75	
Letterheads and envelopes	70.55	
Envelopes and letters for membership committee	12.75	
Letters for membership committee	7.50	
Returns on envelopes, treasurer	2.50	101.05
Refund on advertising check	16.00	16.00
Bad check	2.50	2.50
National Council expenses	5.58	5.58
Journal Committee expenses	35.25	35.25
Total paid out		$2,663.61

E. S. MARTIN, *Treasurer.*

THE CHEMISTRY SECTION.

The Chemistry Section of the Central Association of Science and Mathematics Teachers met Friday P. M., Nov. 30 in Room 20, Kent Chemical Laboratory, Chicago University. The Chairman, Andrew F. McLeod of the Crane Junior College, Chicago, presided. Mr. McLeod mentioned the fact that we were meeting in Alexander Smith's former lecture room, and this led to expressions of appreciation of the work of Alexander Smith as a teacher, following which the



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members of the section stood a moment in silent tribute to his memory.

An invitation was extended by the chairman to any chemistry teacher to be present at any of the monthly meetings of the Chicago Chemical Society.

The nominating committee appointed by the chairman was as follows: Mr. Beck, Mr. Davis, Mr. McLeod.

The first address of the afternoon was by Dr. W. L. Badger, Professor of Engineering Chemistry, University of Michigan; his subject was "Transmutation of Metals—Historical Treatment." The address was intensely interesting and of much historic value. The original sources of the information presented showed us the alchemist as following the best thought of his time. Publication of the address in full is much desired.

The next address on the program was "Humanizing the Teaching of Chemistry in College" by Andrew F. McLeod. In order to give time for discussion at the close of the program, Dr. McLeod omitted his own paper.

"Humanizing the Teaching of Chemistry in the High School" was given by Paul G. Edwards of Crane Technical High School, Chicago. Mr. Edwards was recently made director of all the science work in Chicago grade and high schools. He said, "By humanizing chemistry, I presume we mean, (first) bringing an understanding and a working knowledge of chemistry into the daily activities in which we engage; (second) using the truth of science, especially chemistry, to assist in the formation of habits of character such as honesty, exactness, fair play and thoroughness; (third) developing a scientific method of thought." Mr. Edwards outlined the work given in the chemistry courses in the Crane Technical High and discussed some of the methods in use there. Formulae are introduced early in the work, the first week. Drill and five minute tests become daily routine. The study of chemical changes introduces chemical equations. The discussion of Mr. Edwards' paper was led by Raymond R. Jared of Cass Technical High School, Detroit. His ideas were much in accord with those of the previous speaker. He added a number of devices for stimulating interest and creating a willingness on the part of the pupils to work. The address and the discussion gave valuable material for the teacher of beginning chemistry.

In the general discussion at the close of the program, the following were noted: When should formulae and equations be introduced? The question of demonstration tables versus pupils' laboratory needs further investigation. We should not leave wholly to Universities and Schools of Education the solutions of our teaching problems but rather by the application of scientific methods which we advocate seek their solution for ourselves. In the training of a teacher, what should be the relation of the time spent on the content of the subject, or subjects, to be taught and that spent on the methods of instruction? Emphasis is to be placed on the importance of right training in laboratory work since that kind only leads to the development of good citizenship.

The nominating committee reported the following: for chairman, Raymond R. Jaed, Cass Technical High School, Detroit, Mich.; for vice-chairman, G. T. Franklin, Lane Technical High School, Chicago; for secretary, Mary A. Doherty, High School, Kenosha, Wis. The report was accepted and the nominees declared duly elected as officers of the Chemistry Section for the ensuing year. The meeting adjourned.

FRANCES CHURCH, *Secretary.*

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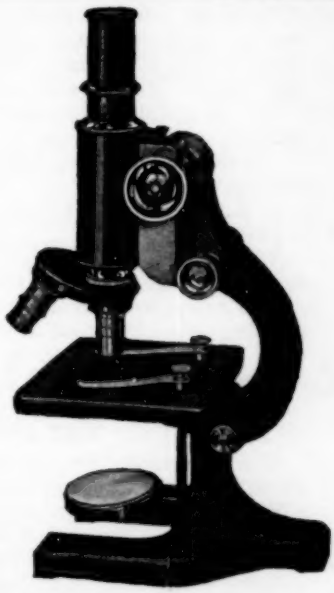

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THE GENERAL SCIENCE SECTION.

The General Science Section Meeting of the Twenty-eighth meeting of the Central Association of Science and Mathematics Teachers Incorporated was called to order at 1:30 P. M. November 30, 1928, by Chairman J. O. Frank of the State Teachers College, Oshkosh, Wisconsin. The usual announcements were made, following which a very splendid program was offered. The program included the following papers:

The Science of the Elementary School and Its Relation to the Science of the Junior High School, by Dr. Gerald S. Craig, Teachers College, Columbia University.

Tests in General Science—Who, What, Why, When, Where, How? by Prof. Harry A. Cunningham, Kent State Normal College, Kent, Ohio.

Newer Teaching Procedures in High School Science with Special Reference to General Science, by Dr. Ralph K. Watkins, College of Education, University of Missouri.

Supplementary Aids in Teaching General Science, by Prof. Ellis C. Persing, School of Education, Western Reserve University, Cleveland, Ohio.

Some First Hand Information Concerning Science Clubs, by Dr. H. A. Webb, George Peabody College for Teachers, Nashville, Tenn.

A lengthy discussion followed the regular program of papers. The chief topics of discussion were about the use and preparation of lesson guide sheets, the selection of the content of General Science courses, the grading of science material from lower to higher levels and the interest factor in science writing.

The discussion touched upon most of the problems from the field of General Science teaching. It brought forth contributions from the leaders in the field. Especial mention should be made of contributions from Chairman Frank and Dr. H. A. Webb, the dean of General Science writers and investigators.

The nominating committee then offered the following slate of officers:

Harvey F. Johnson, Chairman, Proviso High School, Maywood, Illinois.

C. L. Thiele, Vice-Chairman, Director of Exact Sciences, Detroit, Michigan.

W. L. Beauchamp, Secretary, University High School, The University of Chicago, Chicago, Illinois.

The committee's recommendation was unanimously adopted. The meeting was adjourned at 4:30 P. M.

Respectfully submitted,

C. L. THIELE, *Secretary.*

THE GEOGRAPHY SECTION.

The Geography Section met in Room 16, Rosenwald Building at 1:30 Friday afternoon, November 30, the chairman, Mr. Baird, presiding. The first paper presented was "The Contract Method in High School Commercial Georgraphy" by H. O. Lathrop, State Normal School, Whitewater, Wis. Prof. Lathrop blames the compulsory attendance laws for the indifferent attitude of pupils. The contract method, by individualizing instruction, holds the interest of the quick student while allowing the slow student time to understand his work. Three to five day contracts prove most satisfactory.

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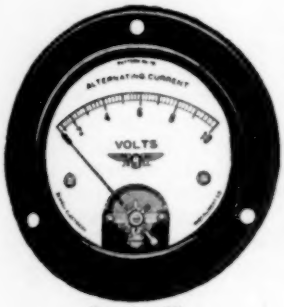

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Mr. Finley of Austin High School, in discussing the paper, granted that the method is more stimulating and gives pupils a better grasp of the subject, but noted several disadvantages. There is less discussion time for the teacher and less drill. Many schools would have difficulty in sècuring the necessary number of reference books and magazines and in getting the outlines mimeographed.

Miss Erna Grassmuck, head of the Geography Department of the State Teachers' College at Indiana, Penna., followed with "Some Specific Challenges in Secondary Geography." The goal should be education of the child through geography to earn a better living and to develop helpful leisure habits. See that land forms are thoroughly understood through pictures before allowing the child to use the map. It is never safe to assume such an understanding. Geography should create an interest in the lives of people elsewhere and give children an appreciation of other races through understanding of the environments in which they live.

The last number of an exceptionally interesting program was a discussion by Wellington D. Jones of Chicago University of "India, a Land with Too Many People?" Mr. Jones pointed out that the question mark was essential because he would not presume to assert that there really were too many. He pointed out, however, that the population, almost entirely rural, is many times as dense as in the United States. Except in the dry northwest, where more land might be irrigated, and the rainy northeast, where more might be cleared, every acre is used to the utmost.

The following officers were elected for 1929: Chairman, Dr. U. S. Grant, Northwestern University; Vice-Chairman, Frederick T. Wilhelms, Bowen High School, Chicago; Secretary, T. A. Finley, Austin High School, Chicago.

HELEN A. SOUTHGATE, *Secretary Pro-tem.*

THE MATHEMATICS SECTION.

The meeting was called to order by the chairman, Edwin W. Schreiber, Ann Arbor, Mich.

Since it was necessary for Prof. Louis C. Karpinski to leave the meeting early, he was introduced by Mr. Schreiber as the first speaker on the program. Prof. Karpinski, University of Michigan, Ann Arbor, Michigan, gave a very interesting talk on, "Worthwhile Literature in the History of Mathematics Desirable for the Teacher in Secondary Schools." Prof. Karpinski classified the literature under two headings: (1) That which is of interest and value to the pupil, and which should be in every high school library. (2) That which is of interest and value to the teacher, but beyond the scope of the pupil.

In the absence of Mr. Nyberg the discussion was led by Dr. Slaught, who made several valuable additions to the list proposed by Prof. Karpinski.

It was moved and seconded that Prof. Karpinski be nominated for honorary membership in the Mathematics Section of the Central Association of Science and Mathematics Teachers. This motion was unanimously accepted and was submitted by the secretary to Mr. J. W. Phillips, Chairman of the Resolutions Committee, for action at the Annual Business Meeting, on Saturday, December 1st, 1928.

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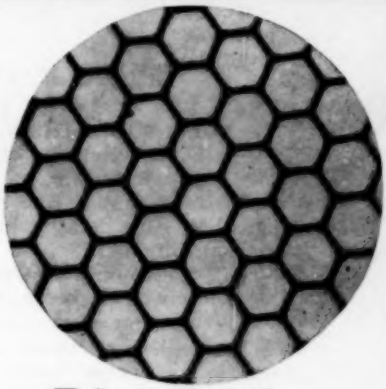

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The minutes of the 1927 meeting which was held at Cass Technical High School, Detroit, were then read.

Miss Mary A. Potter, of Racine, Wisconsin, next gave a paper on "The Drift in Junior High School Mathematics." The discussion was led by Miss Martha Hildebrandt, of Proviso Township High School, Maywood, Illinois.

Mr. C. J. Leonard, of Cass Technical High School, Detroit, Michigan, then gave a paper on, "Mathematics in Industry." Mr. Leonard showed a number of problems which had been brought in by men in the evening school classes in Detroit. A discussion was led by Mr. Marx Holt, Principal Seward School, Chicago, Ill.

The chairman appointed a Nominating Committee of three. Mr. W. W. Hart, chairman, submitted the following report which was accepted: Chairman, Martha Hildebrandt, Proviso Township High School, Maywood, Ill.; Vice-Chairman, J. W. Hoge, University of Chicago, Chicago, Ill.; Secretary, Margaret Dady, Waukegan Township High School, Waukegan, Ill.

More than seventy-five persons were in attendance at the Mathematics Section.

MARGARET DADY, *Secretary.*

THE PHYSICS SECTION.

The meeting was held in the Physics Building of the Chicago University. Admission was by card only. Seventy-seven members were present.

The meeting was called to order at 1:50 P. M. by the chairman, J. M. Kurtz, Bowen High School, Chicago.

The following nominating committee was appointed by the chairman: Wm. B. Borgers, McKinley High School, Chicago; C. C. Taggart, Proviso Township High School, Maywood, Ill.; Owen J. Yoder, Nappanee, Ind.

The Committee on Resolutions presented the following resolution which was adopted by the Section:

The Physics Section of the Central Association of Science and Mathematics Teachers recommends that the Association appoint a Research Committee and that it shall be the duty of this committee to collect data on fundamental aims in science teaching and preparation of science teachers with a view to establishing an adequate definition of aims and an adequate standard of teacher preparation and that it shall be the further duty of this committee to cooperate with committees of other organizations having similar aims and to invite cooperation from such organizations as in their opinion are prepared to aid in the work.

The Committee on Resolutions were: Elmer E. Burns, Austin High School, Chicago, Chairman; R. S. Howard, High School, Lagrange, Ill.; Charles M. Turton, Bowen High School, Chicago.

The following interesting program was then given:

The Teaching of Archimedes' Principle and Its Applications

Major G. B. Eisenhard, Culver Military Academy, Culver, Ind.

Research in Acoustics

Dr. Paul E. Sabine, Riverbank Laboratories, Geneva, Ill.

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M. J. W. Phillips, High School, West Allis, Wis.

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A. W. Augur, Tilden Technical High School, Chicago, Ill.

Papers or abstracts of all numbers on the program will be printed in the Journal of the Association in due time.

The Committee on Nominations presented the following report which was accepted by the Section: Chairman, Ellsworth S. Obourn, John Burroughs School, Clayton, Mo.; Vice-Chairman, H. Clyde Krenerick, North Division High School, Milwaukee, Wis.; Secretary, H. G. Burns, Marshall High School, Chicago, Ill.

Meeting adjourned at 4:45.

H. CLYDE KRENERICK, *Secretary.*

MEETING OF THE NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION, SYRACUSE, N. Y., DEC. 27-28.

The thirtieth annual meeting of the N. Y. State Science Teachers' Association was the most successful of recent years. More attended the meeting and more was done in the interest of science teaching than for some time past. A splendid program was presented by President Baird, East High School, Rochester, which included Dr. Murlin, of Rochester University Medical School, who spoke upon "The Energetics of the Human Body," and Dr. Finegan, of the Eastman Teaching Films, who gave a talk and a demonstration of Classroom Films. But most important was the progress made in crystallizing the desires of the Association into a constructive request to the State Department for the establishing of a twelve year sequence in science.

Mr. Warren W. Knox was unable to be present at the meetings, due to illness in his family, but kindly forwarded eight recommendations which he would have made in person had he been able to be present. These recommendations were as follows:

1. That the secondary schools of N. Y. State be encouraged to gradually introduce general science in the ninth year.
2. That teacher training institutions of N. Y. State be advised of the need of general science training for teachers.
3. That general biology be gradually introduced into the second year of high school work in keeping with the general science program.
4. That a syllabus in a state course in general biology, elective the tenth year be constructed as a sequence to general science the prerequisite.
5. That the proposal for a three year sequence of biological subjects be refused.
6. That any sequence of sciences, with general science as the first regular high school course, be approved.
7. That credit be given for both general science and the reorganized biology course.
8. That credit should be given in advanced zoology and botany when these subjects are taught in the eleventh and twelfth grades and when they follow general science or general biology as a prerequisite.

The Association took no direct action upon these recommendations although indirect action was taken in voting for the resolutions

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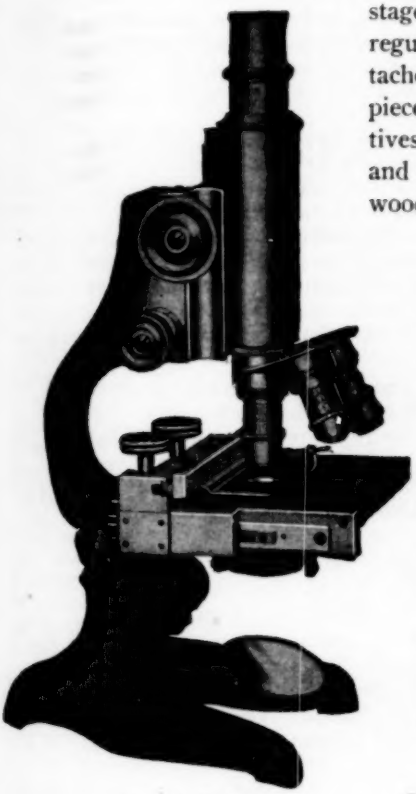

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offered by the resolution committee and voting against the two resolutions tabled at last year's meeting. These last two resolutions, which were rejected by vote of the Association were:

1. Resolved: That the State Department of Education be requested to establish the following sequence in science—Ninth year, general science *(required);* tenth year, biology; eleventh and twelfth years, physiography, chemistry, or physics, to become effective Sept. 1930.

2. Resolved: That the State Department be requested to give a trial use of the open-textbook type of examination in science.

After passing resolutions of appreciation to C. E. Baer, for his work as Science Supervisor of the state, and to the Associated Academic Principals' Association, the Hotel Syracuse, and Superintendent Alverson for their help and cooperation, two other very important resolutions were passed, which are of interest to all science teachers in the state.

1. Resolved; That the State Science Teachers' Association favor an articulated and interdependent course in science education for the elementary and junior-senior high school levels which will adequately provide for the needs of the child at each grade level.

It is further resolved that the State Educational Department be requested to appoint a committee of science teachers, including the State Supervisor of Science, to formulate plans for a twelve-year science course having dependent continuity.

It is further recommended that the study of the last six years be undertaken first.

2. Resolved: That, whereas the plan used in awarding state scholarships reacts unfavorably towards pupils who are scientifically-minded rather than language-minded, be it therefore resolved that the president appoint a committee of three to investigate and recommend remedial measures, this committee to report as soon as possible to the Council, through the Cabinet, for the Council to take immediate action.

The officers elected for the following year are: President, Mr. Harlan P. Freeman; Vice-President, Mr. K. M. Humphrey; Secretary-Treasurer, A. J. Burdick, Utica Free Academy, Utica, N. Y.

The council for the year consists of the above officers, the seven zone science section chairmen, and from the state at large, Ray Spear, G. W. Fowler, Charles Harris, Dr. C. N. Cobb, H. L. F. Morse, John A. Baird, C. J. Wood, Roy H. Mason. The State Supervisor of Science, Warren W. Knox, is also a member of the council, ex-officio.

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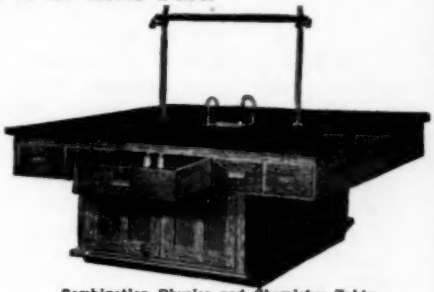

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like a male sex gland; in five out of the 175 operated fowl it even contained mature spermatozoa.

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MOLECULES IN DYNAMITE.

By Dr. R. E. Rose,

E. I. du Pont de Nemours & Co., Wilmington, Del.

Air is a mixture of molecules. These are moving very fast. On a frosty day their average speed is about one-quarter mile each second or 900 miles an hour. When they move 935 miles an hour you feel comfortably warm, when they race 951 miles an hour you feel disagreeably hot. These are the little things that make or unmake our happiness. You do not feel the air molecules strike you but you feel the effect they have on the activity of the molecules of your body. On a very moist hot day you are particularly unhappy because you cannot lose the lively water molecules from your skin, leaving the cooler ones behind.

It is amazing what a speeding up of molecular motion will accomplish. A stick of dynamite, that most useful of modern conveniences, is nothing more than a package of molecules that can be caused to turn into others moving with a velocity that amounts to three quarters of a mile per second. The molecules in the dynamite are built like a top-heavy house with weak members. The nitroglycerine and the ammonium nitrate are just in this condition, give them a knock and over they go, only the knock has to be of a particular kind to make sure of results. But the fragments of molecules are new molecules and these do not settle like the dust from a falling house, they fly in all directions, spurred on by the energy which was tied up in the explosive materials.

The farmer, blowing up a stump, takes a fuse which contains fulminate of mercury, a frightfully sensitive kind of molecule. He fits this on a fuse, crimps it tight, takes a stick of dynamite and makes a hole in it into which he shoves the cap, then, the fuse being fastened, he puts the dynamite in a hole under the stump, puts more sticks of dynamite in, then rams them home and covers them with earth. Then he starts the molecules moving. Those on a match head get lively enough when excited by the heat of friction on his pants, the match stick starts burning, the molecules of the flame upset the molecules in the fuse. Then the farmers runs to shelter and the next moment the spurt of fiery molecules from the fuse hits those of the fulminate in the cap. Away they go smashing the metal cap to pieces and hitting the dynamite a knock-out blow, the whole mass topples to pieces and the pieces push against the earth and against the stump—up goes the stump, lifted by particles of which forty million edge to edge would measure only one inch.

The control of molecular speed is the underlying fact upon which our civilization is built.

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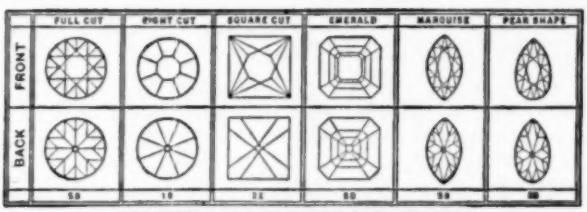

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At the New York meeting of the Mathematical Association, the following officers for 1929 were elected: President, Professor J. W. Young, Dartmouth College; Vice-Presidents, Professor E. T. Bell, California Institute of Technology, Professor W. C. Graustein, Harvard University; Trustees to serve three years: Professor Florian Cajori, University of California, Professor J. L. Coolidge, Harvard University, Professor W. B. Ford, University of Michigan, Professor Oswald Veblen, Princeton University.

Professor E. R. Smith, State College of Iowa, was elected Trustee to fill the vacancy occasioned by the election of Professor Bell as Vice-President.

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(1) Film—"Bavaria"—a prelude for the lecturer, whose education was obtained in the schools of Europe.

(2) Lecture—"The Future of Electrical Engineering as a Vocation"—Mr. Theodore Blech, District Manager of the Northern Illinois Public Service Company, Waukegan, Ill.

(3) Songs—Boys' Glee Club.

(4) Film—"Dexterity and Mimicry of Insects" (1 reel).

(5) Talk—"Volcanoes with special references to related theories and to Kilauea"—Student member, Harold Harrison.

(6) Film—"Kilauea Volcano" (1 reel)

(7) Reading in dialect—Student member, Richard Lounds.

Actual time: One hour and thirty minutes.

Cost to club: $1.27; expressage on film.

TIDES MAY CAUSE SUN SPOTS.

Tides on the sun, caused by the pull of the planets Jupiter and Saturn, may be responsible for the approximately eleven-year period in which the sun-spots wax and wane. This theory, presented about thirty years ago by Prof. E. W. Brown, of Yale University, finds support in evidence presented by Prof. Dinsmore Alter, of the University of Kansas. The sunspot epochs for the past thirty years have almost exactly followed the course predicted in Prof. Brown's paper, he stated.

As the moon revolves around the earth, its gravitational pull attracts the ocean areas to a considerable extent, which is evidenced as the tides. As the mass of the sun is so much greater than that of the earth its own gravitational attraction is very great. With the planets so much farther away than the moon is from the earth, the planetary tides would be very feeble. However, spectrum observations have shown that the atmosphere of the sun is almost in perfect equilibrium. The gravitational force pulling it inward is compensated for by the force of the light pushing it outward. In a body as large as the sun, this radiation pressure is very great. With such an equilibrium, said Prof. Alter, a very slight tidal effect would produce large results.—*Science News Letter.*

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